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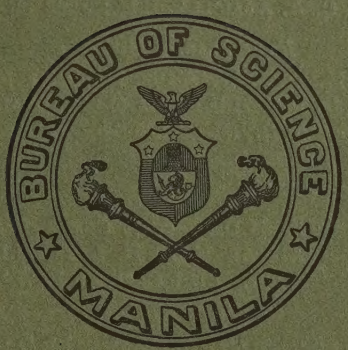

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VOL. 69 JULY, 1939 No. 3

OTTO SCHÖBL

By CIRILO B. PEREZ

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ONE PLATE

Dr. Otto Schöbl, former Chief of the Division of Biology of the Bureau of Science, died in Tokyo, Japan, October 13, 1938, at the age of 61, following a brief illness. Doctor Schöbl was instrumental in the organization of the Bureau of Science laboratory for the large-scale manufacture of biological products. The members of his staff still point with pride to the accomplishments of this laboratory.

Doctor Schöbl was born in Zdice, Czechoslovakia, August 27, 1877. He received his M. D. degree in 1904 from the Government University of Prague, Austria. During his undergraduate years he was appointed assistant. After his graduation in medicine, Doctor Schöbl had three years of practical experience in bacteriology and pathology in Austria.

In 1907 he went to America, and from that time till 1911 he was employed by H. K. Mulford, manufacturing chemists, Philadelphia, one of the largest concerns of its kind in America. In this establishment he gained intimate knowledge of the manufacture of vaccines and sera. March 18, 1912, he accepted an appointment as pathologist in the Bureau of Science. He returned to the United States April 1, 1915. While in the United States, he resigned from the Bureau of Science and accepted a position in the New York State Quarantine Service where he continued the work he had begun in the Philippines on experimental cholera carriers. His return to the Bureau of Science in 1916 was very much appreciated by the Philippine Government on account of his years of experience and wide training in pathology and bacteriology. From 1916 until his

retirement in 1932 he was the Chief of the Serum Section, later known as the Division of Biology.

Doctor Schöbl arrived in the Philippines at the time when the Islands, facing the serious problems growing out of the ravages of tropical diseases, needed a man of his caliber and training. He threw himself wholeheartedly into the study of cholera, dysentery, smallpox, plague, and typhoid, turning his attention more and more to research on vaccines and immunity, studies in which he made notable contributions. The highly developed biological products prepared in the Bureau of Science are in a large measure the outward embodiment of the painstaking work of Doctor Schöbl. The researches of the Bureau of Science on tropical medicine and the improvement of biological products under Doctor Schöbl's supervision were mainly responsible for the eradication in the Philippines of epidemics like cholera, dysentery, typhoid, and smallpox.

Ageing, and his vitality undermined by hard, confined work, he was advised by his doctors to have a change of climate. Following his retirement in 1932 he went to Tokyo, the land of his adoption, and taught in several medical colleges. In 1934 he was decorated by the Japanese government with the order of the Rising Sun, fourth class, for investigations on framboesia (yaws), carried on in the Philippines in collaboration with Japanese researchers. This honor is considered a rare distinction, for only few presidents of Japanese universities have received such an award even after 20 years of distinguished service to their government. Doctor Schöbl was accorded the distinct recognition which comes to a man of the highest scientific standing.

In 1918 Doctor Schöbl was elected president of the Manila Medical Society—a proof of the confidence of American and Filipino physicians in his integrity. For many years he was on the editorial board of the Philippine Journal of Science. In 1923 he served as a member of the Philippine Relief Mission to Japan. His work on this Mission was highly commended, as shown by the following letter:

Aboard the U. S. A. T. "Somme"
October 22, 1923

The Director,
Bureau of Science,
Manila, P. I.

SIR:

I desire to make of record the very valuable services rendered by Dr. Otto Schöbl, of the Bureau of Science, as a member of the Relief Mission

from the Philippines which recently brought assistance to the devastated areas of Japan.

Doctor Schöbl has at all times been most willing and efficient. He has volunteered for unfamiliar duties and has carried them out with the same fidelity and success that characterizes his professional work in your Bureau. Of attractive personality, he has endeared himself to all members of the Relief Mission. His knowledge of Japan and of the Japanese language has made his advice and services as interpreter of very great value.

I desire to invite favorable consideration of Doctor Schöbl's services, as above, and request that this letter, which has been prepared without his knowledge, be filed with his official record.

Very respectfully,

(SGD.) E. L. MUNSON
Colonel, Medical Corps, U. S. A.
Chief Surgeon, Japan Relief Mission.

Doctor Schöbl's position in the scientific world rests on his work done in the Bureau of Science, some of it in collaboration with his assistants. He made for himself and for the Bureau of Science an enduring reputation in the fields of bacteriology and pathology. An examination of his writings reveals plainly his versatility and scholarly presentation of his subjects, of which the most important are yaws, syphilis, leprosy, rat-bite fever, cholera, dysentery, and typhoid. He wrote 84 articles published in several journals, chiefly in the Philippine Journal of Science. His knowledge of the English, Spanish, German, Japanese, and Czech languages made his services of great value.

Doctor Schöbl had the universal respect and admiration of all who knew him. One always recognized in him the painstaking devotion to duty, simplicity, and quiet sincerity which are traditionally attributed to a true scientist. Doctor Schöbl is dead, but his accomplishments stand clearly recorded in the annals of science and in the memories of his colleagues. Several countries will feel proud of the scientific heritage that Doctor Schöbl left. He was born and raised in Czechoslovakia, educated in Austria, engaged in research work in the United States and for the Philippine Government for almost 20 years, and died a Japanese citizen.

Doctor Schöbl is survived by his Japanese wife and an adopted son.

On the occasion of Doctor Schöbl's death, Dr. Eduardo Quisumbing, then Acting Director of the Bureau of Science, paid the following tribute:

Doctor Schöbl's colleagues in the Bureau of Science are very sorry to learn of his death. Considering the inestimable value of his researches

on tropical medicine and the significance of the biological products which were improved under his supervision and which are mainly responsible for the eradication of epidemics, such as cholera, dysentery, smallpox, and typhoid, Doctor Schöbl's passing is a great loss to the Philippines in particular and to the scientific world in general.

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ILLUSTRATIONS

PLATE 1. OTTO SCHOBL

GENESIS AND MORPHOLOGY OF THE SANDY SOILS OF PAMPANGA AND TARLAC PROVINCES, PHILIPPINES

By Dominador Z. Rosell

Of the Division of Soil Survey, Department of Agriculture and Commerce Manila

THREE PLATES

The region comprising Pampanga and Tarlac Provinces, where this investigation was conducted, is a part of the Great Central Plain of Luzon. During the soil survey of these provinces, made in the dry season of 1936, a large area of sandy soils was found, classified, and mapped. This area covers almost one-half of the total area of the two provinces, which is about 518,210 hectares. A great portion of the level land, a total area of approximately 214,765 hectares, extending from the town of San Fernando to the town of Paniqui, a distance of about 85 kilometers, is sandy soil. Sugar cane is the most important crop in this type of soil, Pampanga and Tarlac Provinces deriving most of their income from this crop. The rice crop, next in importance, is grown exclusively in clay-loam soils. Minor crops grown in these sandy soils are peanuts, sweet potatoes, and pineapples and other fruits. Vegetables of various kinds and citrus fruits are quite common in these sandy soils.

The soils as a whole have never been studied. In the opinion of the author a rational approach to the problems of the productivity of these soils involves pedalogical knowledge. It is the object of this investigation to study the origin and the nature or mode of formation of this soil as a whole.

ENVIRONMENTAL FACTORS

Climate.—As in the other provinces of the Great Central plain of Luzon, the climate of Pampanga and Tarlac Provinces consists of alternating wet and dry seasons: wet during the summer and autumn months and dry during the winter and spring months. Heavy rainfall occurs during the latter part of spring until the middle of autumn. The dry season begins during the latter part of autumn and lasts until the middle of spring. The temperature is high and almost constant throughout the year,

except during November, December, and January. The climatic records, including mean annual rainful and temperature of San Fernando and Tarlac towns, are given in Table 1.

TABLE 1.—*Average monthly rainfall and temperature of San Fernando, Pampanga Province, and Tarlac, Tarlac Province.*

Month	San Fernando.			Tarlac.		
	Rainfall 1925–1932.	Temperature, 1925–1931.		Rainfall, 1925–1932.	Temperature, 1925–1931.	
		Maximum.	Minimum.		Maximum.	Minimum.
	mm.	°*C.*	°*C.*	*mm.*	°*C.*	°*C.*
January	20.8	31.3	19.9	6.7	31.5	19.2
February	11.4	32.2	20.2	10.8	32.5	19.9
March	20.8	33.9	21.1	21.2	33.6	20.9
April	51.9	35.0	22.9	72.1	35.1	22.3
May	215.4	34.3	23.8	215.8	33.6	23.1
June	306.0	32.1	23.9	315.8	31.7	23.3
July	369.3	31.9	23.5	366.5	31.1	23.2
August	362.4	31.2	23.6	439.7	30.9	23.0
September	250.5	31.8	23.5	222.2	31.8	22.8
October	155.6	31.9	22.9	135.5	32.1	22.3
November	75.4	31.2	21.8	40.3	32.0	20.9
December	30.3	30.9	20.3	12.7	31.0	19.0
Mean annual	1,869.8			1,829.3		

Vegetation.—The entire sandy region was once under forest. Today, however, few trees are found, mostly along the foothills and river sides. Woodland savannah is also found along the rolling area below the foothills. Trees scattered here and there include *alibangbang, Bauhinia malabarica* Roxb.; *camachile, Pithecolobium dulce* (Roxb.) Benth.; and *duhat, Eugenia jambolana* Lam. Several bamboos, *Bambusa vulgaris* Schrad. and *Bambusa blumeana* Schultes, and *boho, Schyzostachyum lumampao* (Blanco) Merr., are growing along the rivers and creeks. Grasses like *cogon, Imperata cylindrica* Linn.; *talahib, Saccharum spontaneum* Linn., and *aguingay, Imperata exaltata* Linn., are found in uncultivated areas.

Physiography and geology.—The region is nearly level to gently rolling on the eastern side, and hilly and rolling on the western side. In the lowlands of Pampanga Province the elevation at San Fernando is 20 feet above sea level, gradually increasing to 300 feet at Mabalacat town, decreasing again toward the towns of Bamban, Concepcion, and Capaz, finally dropping to 40 feet above sea level at Paniqui and Moncada towns. The rise and fall in elevation is so gradual as to be hardly perceptible.

The most important rivers of this region are the Pasig, Gumain, and Bamban Rivers of Pampanga Province and the O'Donnell and Tarlac Rivers of Tarlac Province. These rivers control the drainage system of this sandy region.

The geologic map of the Philippines shows that the Great Central Plain consists of piedmont, spring talus, laterites, river deposits and coral reefs. The eastern flank of the Zambales range consists of tertiary and later effusive rocks (rhyolites, dacites, andesites, and basalts). Below this flank is a narrow strip of tuffaceus area.

The sandy area under investigation consists mostly of river deposits of freshly weathered rock material which originated from the eastern flank of the Zambales range. The narrow strip of tuffaceous area is practically covered by these sediments. The rocks from which these sediments were derived consist of andesites, mostly feldspathic andesite porphyry and hornblende, and feldspathic andesite porphyry (Plate 2).

MORPHOLOGY

Soil series and types.—During the soil survey of Pampanga and Tarlac Provinces three series of sandy soils were established and mapped. The Angeles and La Paz series are found both in Pampanga and Tarlac Provinces, while the Luisita series is found only in Tarlac Province. A study of the different soil profiles of these three series reveals similarity in soil formation. The variation in the depth of various horizons, coarseness in texture, color, structure, and consistency are due largely to the elevation, topography, and drainage of the area. The surface soil of the undisturbed area is more compact than the surface soil of the cultivated area.

The Angeles series has a pale brownish-gray, pale or ash-gray, to nearly whitish-gray surface soil. The subsoil is brownish-gray to light reddish-brown sand containing gravel. The substratum is sand to coarse sand containing gravel and sandstones. There are four types in this series; namely, coarse sand, sand, fine sand, and sandy loam. The La Paz series consists of fine sand in the subsoil, similar to the Angeles series. The substratum consists of medium to fine sand without gravel. There are two types in the series; namely, fine sand and fine sandy loam. The Luisita series consists of coarse sand in the subsoil and coarse sand containing soft tuffaceous concretions and gravel in the substratum. There are three types of soil; namely, fine sand, sandy loam, and fine sandy loam.

Profile characteristics.—Several soil profiles of the three series of the sandy soils were studied. The morphological characteristics of one representative type of each series will be presented.

The fine sandy type of the Angeles series occupies a wide area in Pampanga. A typical profile of this type obtained at barrio Dolores, Mabalacat town, shows the morphological characteristics of the different horizons.

ANGELES FINE SAND

Depth of soil. cm.	Characteristics.
0 to 30	Pale brownish-gray, loose, and structureless fine sand; decayed roots and leaves present; pH, 6.77.
30 to 50	Brown to light reddish-brown medium sand with sandstones and gravel; decayed roots and leaves present; pH, 6.55.
50 to 75	Mixture of pale-gray to nearly white sand and reddish-brown gravel; decayed roots of trees present; pH, 6.44.
75 to 95	Same as above but with more gravel; no roots; pH, 6.44.
95 to 110	Gray coarse to medium sand, structureless; sand resembling silica present; pH, 6.30.
110 to 150	Sandstone, grayish white, coarse, and gritty; pH, 6.30.

The mechanical analyses of the profile samples of this type are shown in Table 2.

TABLE 2.—*Mechanical analyses of the profile of Angeles fine sand.*

Depth of horizon.	Coarse sand, 0.2–0.22 mm.	Medium sand, 0.22–14 mm.	Fine sand. 0.14–0.07 mm.	Very fine sand, 0.07–0.05 mm.	Silt and clay, 0.05 mm.
cm.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0– 30	47.3	16.5	11.9	6.2	18.1
30– 50	52.2	16.3	8.5	12.0	11.0
50– 75	64.8	19.2	5.5	7.2	3.3
75– 95	68.8	15.6	5.0	3.6	7.0
95–110	66.8	15.7	6.2	5.0	6.3
110–150	60.8	21.0	6.5	4.8	6.9

Except for the texture of the surface soils, the analyses of the samples of the other types of the Angeles series show fundamental similarity to the profile samples of the fine sand type.

The La Paz series is represented by the La Paz sandy loam type. It was established in the vicinity of barrio La Paz between the towns of San Fernando and Angeles. This type is also found in Tarlac Province. The profile of La Paz fine sandy loam obtained at Barrio Salomagui, town of Paniqui, shows the following characteristics:

LA PAZ SERIES

Depth of soil. cm.	Characteristics.
0– 50	Light gray to gray fine sandy loam, structureless and slightly compact; pH, 6.55.
50–110	Grayish-brown to yellowish-brown fine sand, cloddy to nutty in structure; pH, 6.19.
110–150	Brownish-gray to brown coarse sand, loose and wet; zone of water table; pH, 6.27.

The mechanical analyses of these profile samples are shown in Table 3.

TABLE 3.—*Mechanical analyses of the profile of La Paz fine sandy loam type.*

Depth of horizon.	Coarse sand, 0.2–0.22 mm.	Medium sand, 0.22–0.14 mm.	Fine sand, 0.14–0.07 mm.	Very fine sand, 0.07–0.05 mm.	Silt and clay, 0.05 mm.
cm.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0– 50	1.5	12.3	13.4	21.0	51.8
50–110	1.0	2.0	18.6	35.5	42.9
110–150	0	23.0	36.3	19.0	21.7

The Luisita series was established and mapped within the vicinity of Hacienda Luisita, Tarlac Province. The soils with no irrigation are mostly utilized for sugar cane, while the areas with irrigation are planted to rice. The profile of the Luisita sandy loam was obtained within Hacienda Luisita.

LUISITA SANDY LOAM

Depth of soil. cm.	Characteristics.
0– 40	Brownish-gray to gray, loose and structureless sandy loam; pH, 6.46.
40– 80	Brownish-gray coarse sand with small amount of clay; almost compact; pH, 6.24.
80–150	Coarse sand with tuffaceous concretions and gravel; loose and coarse, granular; pH, 6.19.

The mechanical analyses of the profile samples are shown in Table 4.

TABLE 4.—*Mechanical analyses of the profile of Luisita sandy loam type.*

Depth of horizon.	Coarse sand, 0.2–0.22 mm.	Medium sand, 0.22–0.14 mm.	Fine sand, 0.14–0.07 mm.	Very fine sand, 0.07–0.05 mm.	Silt and clay, 0.05 mm.
cm.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
0– 40	22.0	18.5	10.3	13.0	36.2
40– 80	50.7	13.7	7.2	7.0	21.4
80–150	62.7	8.9	5.5	4.4	19.5

The other types of the Luisita series show similar horizons, although the mechanical analyses of the samples vary slightly from one another.

GENESIS OF THE SANDY SOILS

GENERAL DISCUSSION

The evolution of the complex constitution and habitus or general appearance of the soil body in relation to the natural laws responsible for its origin is known as soil genesis. It is controlled by a series of natural forces guided by definite natural laws which find expression through the factors known as "soil formers".(7)

Kellogg in his discussion on the factors of soil genesis gave the following equations responsible for the development of soil:

$$\text{Soil} = \int \text{Climate, vegetation, relief, age, and parent material.}(9)$$

Shaw,(12) discussing the potent factors in soil formation, gave a similar formula, according to which the soil is formed from the parent material by climatic factors and vegetation through time. Shaw pointed out that the character of the parent material, its composition, density, and the rate at which it may be modified by the influence of climate and vegetation, has a persistent effect in determining the character of the resulting soil.

The sandy region of Pampanga and Tarlac Provinces may be considered as a constructive process of sedimentation. The practically exposed condition of the eastern flank of the Zambales Range bordering Tarlac and Pampanga Provinces, which is at the mercy of a warm and humid climate, makes for the exceptionally rapid weathering of the andesitic rocks. The torrential nature of the summer rains removes the deconsolidated materials as fast as they are weathered. These materials are brought down by the torrential and intermittent streams and deposited in the plain as the water loses its carrying power. It appears, however, that the foundation has been subsiding at about the rate of accumulation so that the surface of the deposition has maintained nearly the same level.(13) Such great amounts of fresh material, consisting mostly of sand, silt, and a significant amount of clay, are considered in a strict sense as parent material upon which the soil will develop.

The development of this material into a mature soil depends upon the factors or soil formers mentioned in the first part of this discussion. Under the influence of climate, vegetation, relief, and time this material will reach a stage where a soil will be formed. At this stage the surface or "A" horizon and the

subsoil or "B" horizon will be differentiated from the parent material. This formation, however, requires considerable time. In the initial stage of its development the characteristics of the soil are inherited from the parent material.

The three series of sandy soils of these provinces consist mostly of sandy material from the surface down to a depth of more than three meters. There is no differentiation between the surface or "A" horizon and the subsoil or "B" horizon. The most important characteristics of the profile include the characteristics of the sandy material consisting of weathered andesitic rock, which is also the parent material of the developing soil. Thus the sandy soil is in the early stage of development and may be considered young soil. The presence of decayed plant residue in the surface soil is part of the work of vegetation and climate. Continuous cultivation of the area disturbs the development of the soil. The leaching of the different salts and other plant-food elements to the substratum is unchecked during the rainy season, because there is no hardpan or fine material accumulation in the lower portion of the profile. During the dry season, however, these substances are brought up again by means of excessive capillary action and evaporation.

In wet areas the excess water during the rainy season flows readily, carrying with it whatever loose fine material is on the surface. Thus the development of these soils is always affected by the erosion of the surface soil. In areas where there is a continuous vegetative cover, the development may proceed until otherwise disturbed by cultivation.

SUMMARY

The morphologic features of the three series of sandy soils of Pampanga and Tarlac Provinces show similarity in profile constitution, pH value, color, and structural arrangement. The sandy soils of the region are in the younger stage of soil development, showing no marked formation of surface or "A" horizon and subsoil or "B" horizon. Due to the structural formation of the profile, leaching is excessive and detrimental during the rainy season. However, there is excellent capillary action during the dry season. The development of the sandy soils resulting from the parent material of recent alluvial deposition of weathered andesitic rock, located on the eastern flank of the Zambales range, is the mode of soil formation.

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ILLUSTRATIONS

PLATE 1

Location and extent of the sandy region within Pampanga and Tarlac Provinces.

PLATE 2

Samples of porphyritic andesite rocks found in river beds; soil profile, and the fields of the sandy soils of Pampanga and Tarlac Provinces.

PLATE 3

FIG. 1. Profile of the Angeles sandy loam soil of the Angeles series. Note the gravel in the substratum.

2. Big landowners in Pampanga and Tarlac prepare their soil for sugar cane by means of tractor and disc plows.

3. A rice field in Angeles fine sand type, located near a river. When the river floods, the water destroys the rice paddies.

4. River bed in Angeles soils. Bamboos help keep the soil in place.

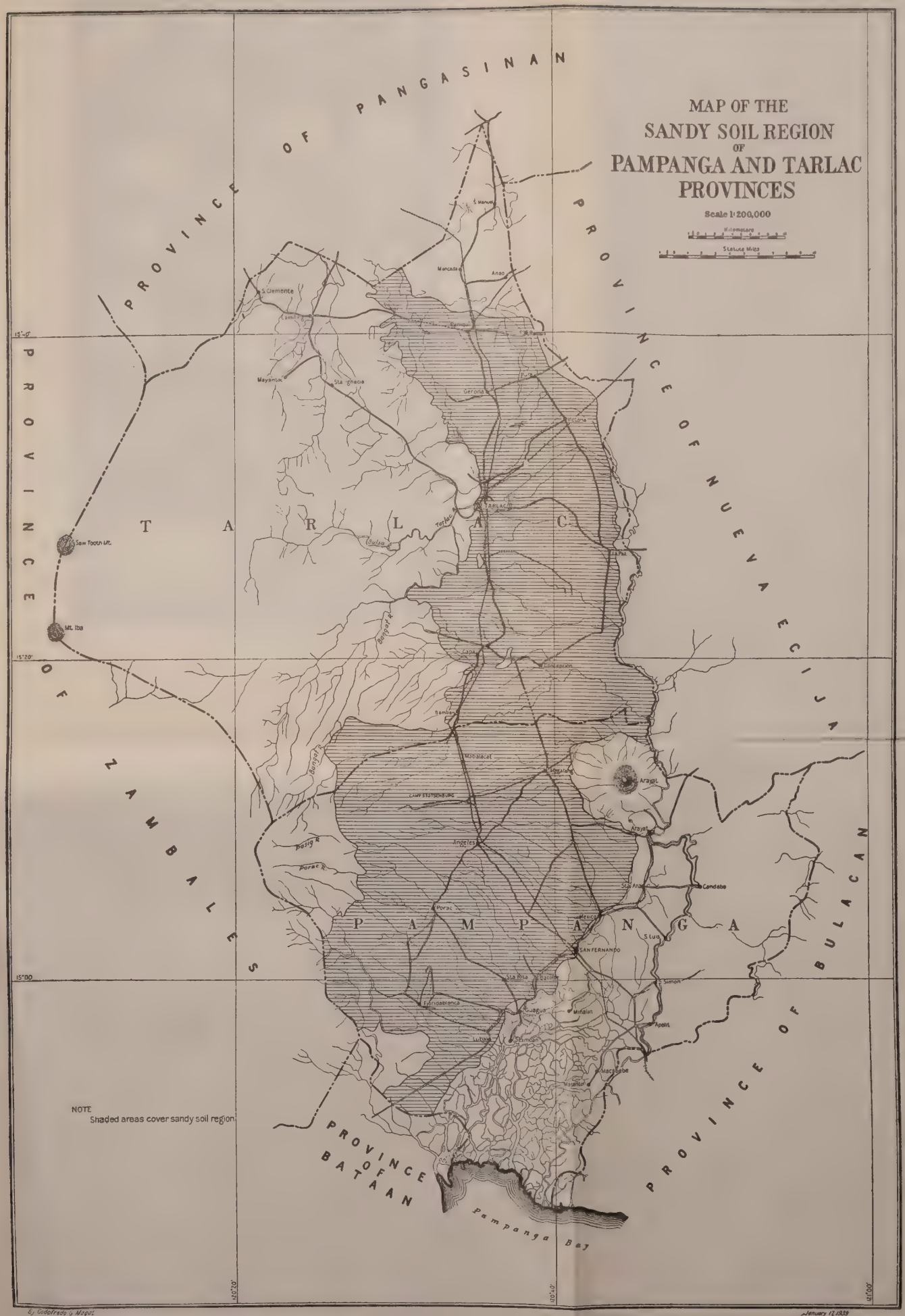

PLATE 1. LOCATION AND EXTENT OF THE SANDY REGION WITHIN PAMPANGA AND TARLAC PROVINCES.

PLATE 2.

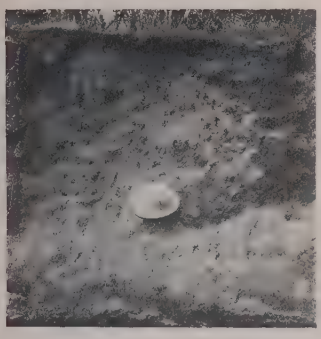

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PLATE 3.

AN INTERPRETATION OF EUPHORBIA EDULIS LOUREIRO

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Loureiro published *E. edulis* [1] with the following main diagnosis:

Caulis fruticosus, 6-pedalis, 5-angularis, aculeis geminatis: *ramis* ascendentibus. Folia multa sparsa, sub-cuneiformis, apice rotundata, 3-pollicaria, integerrima, carnosa, glabra. *Corolla* nulla. Calyx 1-phyllus, carnosus, ventricosus, interius ruber, exterius viridis. *Stamina* brevia, 40 circiter. *Capsula* 3-cocca.

Habitat culta in hortis Cochinchinae, puto, quod etiam agrestis.

Usus. Folia elixa cum oleribus comedunt saepe indigenae absque noxa.

From its description *E. edulis* agrees with *E. neriifolia* except for the form of the leaf and the color of the cyathium. It is not *E. nudicaulis,* which Perrotet reported without collecting [2] from the vicinity of Surabaja, Java. Despite its "fleurs rouges" this very questionable spurge cannot be *E. edulis,* because it is described as having long, unarmed, and flexible branches. Nor are *E. neriifolia chinensis* and *E. varians* compatible with *E. edulis* from the descriptions that Haworth gives [3] of them. Inasmuch as the Loureiran diagnosis is the only record of the species, and the type is not extant, *E. edulis* has been considered doubtful or has been reduced with some justification to a synonym or variety of *E. neriifolia.* Merrill urges further investigation and diligent collection; [4] Gagnepain [5] and Boissier [6] believe that *E. edulis* may prove to be a form or a synonym of *E. neriifolia,* though the latter unaccountably misquotes Loureiro to the effect that *E. edulis* has diffuse branches, small leaves, and solitary flowers.

[1] Fl. Cochin. 1 (1790) 298.
[2] Mém. Soc. Linn. 3 (1825) 110.
[3] Syn. Pl. Succ. (1812) 130.
[4] Comm. Fl. Cochin. Proc. Am. Phil. Soc. (2) 24 (1935) 242.
[5] Lecomte, Fl. Gén. Indo-Ch. 5 (1915) 254.
[6] DC. Prodr. (2) 15 (1862) 80.

Loureiro sometimes adapted his diagnoses from Chinese sources or described plants from memory,[7] but it is almost certain that in this case he wrote the account of *E. edulis* with a specimen before him. The less credible of his statements, that the natives use the leaves of *E. edulis* as pot herbs, finds confirmation in the report of a modern collector,[8] who avers that in the Indian desert, at Jodhpur and Jaisalmer, the leaves of *E. neriifolia* are known as "papri" and eaten. From the somewhat confused account of Rumphius [9] it is learned that the leaves of species allied to *E. neriifolia* have a place in the diet of the natives of the Sunda Islands. De Candolle [10] is evidently compiling from Rumphius when stating "Les Éthiopiens [11] mangent les feuilles broyées comme reméde contre les obstructions et les coliques." Not less than four spurges, namely, *E. neriifolia*, *E. Barnhartii* (*E. trigona* Roxb. *non* Haw.), *E. antiquorum* and *E. pulcherrima* are reported by Burkill [12] as edible in various degrees and as actually being made into sweetmeats by Chinese and Malayans. Additional references in the literature can be found to substantiate Loureiro's assertion, and the legitimacy which the specific name *edulis* gives to a *Euphorbia* of this description. The note "stamina 40 circiter" could not have been suggested to Loureiro otherwise than from the study of actual specimens. What, short of actual dissection, revealed to Loureiro that a species of the Dodecandria Trigynia had about three times as many "stamens" as are required by the Linnæan class definition?

Copious evidence from another quarter corroborates Loureiro's reports. A spurge resembling *E. neriifolia* but having a partly red cyathium was cultivated between 1772 and 1824 in public and private gardens of Italy, France, and England.

[7] Merrill, op. cit., 40.

[8] Macadam, in Journ. Bomb. Nat. Hist. Soc. 26 (1920) 970.

[9] Herb. Amb. 4 (1743) 90, 91.

[10] Hist. Pl. Gr. (1799) *pl. 46 cum text.*

[11] Rumphius speaks of *Æthiopes Hitoenses* (op. cit., 90) which manifestly were representatives of the Papuan negroid race variously known as Ahita, Aeta, Attas [Beccari, Nov. Guin. (1924) 437, footnote; Rep. Philip. Comm. 1 (1900) 13]. No reference to *E. neriifolia* is found in De Candolle's work that deals with medicinal plants [Ess. Prop. Méd. Pl. (1816)) 260–265], which further indicates that De Candolle merely compiled his data from Rumphius.

[12] Dict. Econ. Prod. Mal. Pen. (1935) 979–982.

Bonelli [13] illustrated crudely but quite effectively a plant of this description. De Candolle,[14] availing himself of the expert services of Redouté, gave of the same plant a fine likeness. Lamarck, Persoon, Haworth, and Colla knew this plant and apparently no other of its affinity. Lamarck [15] described its cyathium "vert dunâtre mêlé d'un peu de pourpre." Persoon [16] concisely stated that its flowers are red. Haworth,[17] as it seems, deliberately, overlooked the illustrations of Rheede, Plukenet, Commelin, and Bradley, and only referred to the plate of Redouté. Colla [18] also referred to Redouté's illustration. With the exception of Bonelli, who usually does not use Linnæan binomials, all the botanists cited reduced this red-glanded spurge to *E. neriifolia,* though it manifestly agrees neither with the *Ela Calli* of Rheede [19] nor with the *Tithymalus* of Commelin,[20] which are cited by Linnæus [21] in the publication of *E. neriifolia.* De Candolle [22] very nearly discovered that this red-glanded spurge was not the *E. neriifolia* of Linnæus, when he noted that Commelin's *Tithymalus indicus arborescens nerii folio* had long-peduncled cymes, not the subsessile inflorescence of the specimen figured by Redouté.

So far as I can learn the red-glanded spurge resembling *E. neriifolia* first appeared in cultivation in the botanical garden at Rome, a rooted section of stem in flower having been illustrated in 1772. It is significant that this plant was first noticed at the time when Loureiro was busy in his Indochinese apostolate and Maratti, Bonelli, and Sabati were zealously striving to refloat, with the papal blessing, the nearly shipwrecked Orto Romano. Sabbati [23] in particular is represented as very much interested in exotic plants, and had at least five succulent spurges in cultivation despite the fact that the Roman garden lacked hothouse facilities. Though Loureiro evidently preferred to transact his botanic affairs with British followers of the binomial system of classification, his duty as a missionary called for his maintaining continuous contact with Rome, and it is not unlikely that he obliged, with some token, the foremost Roman

[13] Hort. Rom. 15 (1772) *pl. 28.*
[14] Loc. cit.
[15] Enc. Méth. 2 (1786) 415.
[16] Syn. Pl. 2 (1806) 11.
[17] Syn. Pl. Succ. (1812) 130.
[18] Hort. Rip. (1824) 54.
[19] Hort. Malab. 2 (1679) 83, *pl. 42.*
[20] Pl. Rar. Hort. Amstel. 1 (1697) 25.
[21] Sp. Pl. 1 (1753) 451.
[22] Loc. cit.
[23] Hort. Rom. (1772) 8.

botanists of the day. Instances are on record [24] suggesting that the unknown type of a succulent spurge is probably the parent stock of cultivated plants the origins of which are unrecorded. It is well known that early botanists seldom took care to prepare succulent spurges for the herbarium and mostly relied upon live specimens and drawings to typify the binomials. In view of this fact it is reasonable to accept the illustrations of Bonelli and De Candolle as representing typical *E. edulis* Lour. This iconography disagrees with the description of *E. edulis* only in one detail; Loureiro describes a cyathium that has green nectaria (glands) and red lobes, whereas Bonelli and Redouté in their illustrations show that the reverse is true. The discrepancy does not exceed the limits of excusable error, due either to a misprint or to a slip of memory. In my mind Loureiro's binomial must be honored despite the incorrectly recorded sequence of the colors of the cyathium in the original publication of *E. edulis*.

Though unrecognized as such, *E. edulis* is being extensively cultivated throughout the world and is known to most amateurs of succulent plants. For at least forty years it has been grown in the Orto Botanico at Palermo [25] under the misapplied binomial, *E. laurifolia* Lam., which I have been able to ascertain from live material kindly furnished by Prof. D. Lanza, of the staff of that institution. From several correspondents it was sent to me from America, Europe, and Africa, mostly mislabelled *E. neriifolia*. I have never received it from India, however. Recently Prof. F. P. Metcalf, of Lingnan University, found *E. edulis* thriving in the neighborhood of Canton, China. The evidence does not seem to be far from conclusive that Loureiro described a well-known plant and possibly introduced it into cultivation in Europe; that this plant is cultivated throughout the world to this very time; that it occurs in southern China; that, if found in India, it is probably not common there. It may be suspected that *E. edulis* still thrives "in hortis Cochinchinae" because Gagnepain [26] describes a species with subsessile or sessile cyme that hardly is *E. neriifolia*.

Next to nothing is known today of the geographic distribution of *E. edulis*. It probably has the status of a purely southern

[24] Croizat in Bull. Jard. Bot. 15 (1938) 115, footnote 1.
[25] Bull. Ort. Bot. Paler. app. 3 2 (1898) xviii.
[26] Lecomte, Fl. Gén. Indo-Ch. 5 (1915) 240.

Chinese and Indochinese endemic which has achieved nearly pantropic distribution as an ornamental plant. It might on the other hand be found also native to Siam, Burma, and the Philippines. Good material is needed to define the issue and the weight of general evidence suggests that either distributional hypothesis is possible.

Broadly speaking, *E. edulis* is a mutation of *E. neriifolia.* Mutational aggregates are common in *Euphorbia* and often an amazing number of "petites espèces," to use the apt French definition, group themselves around a main form which taxonomists must recognize as the oldest one validly published. The study of such groups can seldom be adequately conducted without an investigation of all the forms included under them. Even in such a cursory review as the present it is necessary to compare *E. edulis* with *E. neriifolia* in order to define the limits of the one as against those of the other species.

It is unfortunate that the greatest difference of opinion prevails among taxonomists as to just what Linnæus had in mind when he published *E. neriifolia.* Hamilton [27] rejected the Linnæan binomial altogether, believing it to be meaningless. Roxburgh [28] and Cooke [29] limited it to the terete-stemmed form understood by them as *E. Nivulia,* and proposed to name *E. ligularia,* the spurge which the majority of taxonomists treat as *E. neriifolia.* Talbot's [30] account is most confused, and it is possible that his *E. ligularia* [31] is in reality an unnamed and undescribed species. Hooker f.[32] reduced the earlier homonym *E. varians* as a synonym of *E. Nivulia* and unaccountably followed Hamilton in accepting Rheede's *Ela Calli* to represent the same form illustrated by Wight [33] as *E. Nivulia.*

There can be no doubt that the references and illustrations used by Linnæus [34] under *E. neriifolia* define a group of species that belong to two different genera and are dissimilar except for accidental likeness of habit. Seba's [35] *Euphorbium* is *Elaeo-*

[27] Trans. Lin. Soc. 15 (1825) 286.
[28] Hort. Beng. (1814) 36; Fl. Ind. 2 (1832) 46.
[29] Fl. Bombay Pres. 2 (1908) 563.
[30] Fl. Bombay Pres. Sind. 2 (1911) 432.
[31] Op. cit., *fig. 485.*
[32] Fl. Brit. Ind. 5 (1887) 255.
[33] Icon. Pl. Ind. Or. (1852) *pl. 1862.*
[34] Sp. Pl. 1 (1753) 451.
[35] Rer. nat. Thes. 1 (1743) 18, *pl. 9, figs. 1, 2.*

phorbia drupifera, from the west coast of Africa. Commelin's [36] two spurges are specifically unrelated. One is believed by most authors to represent *E. varians* (*E. Nivulia*), although in the poor specimen that was illustrated characters pointing to *Elaeophorbia drupifera* are not lacking. The very large leaves, the manifestly tapering growth of the stem, the large rounded spine shields, and the erect habit of the nectaria of the female flower, seem to me to indicate *Elaeophorbia drupifera,* despite Commelin's statement that the specimen illustrated had been sent by van der Pyl, governor of Colombo, Ceylon. The other Commelinian [37] spurge is sterile but is probably not distinct from Rheede's *Ela Calli.* Bradley's [38] illustration is manifestly a copy of Commelin's figure in the Praeludia, but Bradley's specimen was of South African origin and it does not seem probable that Commelin and Bradley had in mind the same species. Plukenet's [39] crude figure does not lend itself to critical discussion, although it may be accepted to represent *E. varians* (*E. Nivulia*). D'Isnard's [40] "Euphorbium No. 8" appears to be the same plant as that illustrated by Commelin in the Praeludia. The elder Burman [41] grossly misinterpreted the "Euphorbium No. 9" of D'Isnard which is almost certainly *E. clava* [42] from the Cape of Good Hope. Burman's animadversion, however, should be noticed, because it suggests that *E. caducifolia* might have been in cultivation and that it was confused with the other species of

[36] Pl. rar. Hort. Amstel. 1 (1697) 25, *fig. 3.*

[37] Prael. Bot. (1703) 22, 56, *fig. 6.*

[38] Hist. Pl. Succ. 3 (1725) 10, *fig. 28.*

[39] Phytogr. (1720) *pl. 230, fig. 4.*

[40] Mém. Acad. Roy. Sc. [1720 (1722)] 386.

[41] Loc. cit.

[42] D'Isnard refers to Plukenet's *Tithymalus* [Phytogr. (1720) *pl. 230, fig. 5*] which appears to be the same plant shown by Petiver [Gazophyl. (1721) *pl. 86, fig. 5*]. The illustrations of Plukenet and Petiver were copied from a collection of drawings belonging to Bishop Compton, of Fulham, and are almost certainly meant to represent *E. loricata.* Compton's drawings in all probability were the work of Hendrik Claudius, a German who accompanied Simon van der Stel in his expedition to Namaqualand [Waterhouse, Sim. Stel Journ. (1932) xx]. The *Tithymalus* of Plukenet and Petiver was found, and sketched, in the vicinity of Oliphant's River (Waterhouse, op. cit., 168, No. 861), which indicates that N. E. Brown errs in excluding [in Dyer's Fl. Cap. (2) 5 (1915) 342] the polynomials of Plukenet and Petiver from the synonymy of *E. loricata.* It is plain that D'Isnard confused *E. clava,* cultivated about 1700, with *E. loricata* which was not in cultivation in Europe before 1780.

the group. Rumphius's [43] *Ligularia* has the habit, broad wing crenation, and the comparatively short, oblong-cuneate leaves of *E. edulis*, and I am inclined to accept it as a satisfactory habit illustration of that species.

A specimen of *E. neriifolia*, which is technically the holotype of the species, is extant in the Linnæan herbarium. Though the photograph of the holotype in question indicates a sterile fragment, it is believed that this fragment cannot represent *E. varians* (*E. Nivulia*). So far as one can judge without actually seeing the specimen, the holotype of *E. neriifolia* agrees with the *Ela Calli* of Rheede and with the *Tithymalus* of Commelin, in the Praeludia. Accordingly I accept Rheede's illustration as typifying *E. neriifolia*.

For the purpose of comparing *E. edulis* and *E. neriifolia* as far as possible under natural conditions, a rooted stem of *E. edulis*, received from the Orto Botanico of Palermo, and one of *E. neriifolia*, sent by Mr. F. C. Osmaston and collected at Hinoo, Ranchi, Bihar, and Orissa, India, were grown and brought contemporaneously into flower. Further comparison was made of this material with the available iconography, with live and preserved specimens of *E. varians* (*E. Nivulia*) and *E. caducifolia*, and with dried samples of *E. neriifolia* and *E. edulis* in the herbarium of the Arnold Arboretum.

Euphorbia edulis and *E. neriifolia* differ as follows:

(*a*) Leaf essentially spatulate in *E. neriifolia*, tapering to a long (about 2 cm) petiole; oblong-cuneate in *E. edulis*, ending into a short (about 1 cm) petiole.

(*b*) Podarium (tooth to the wing or angle) figuring in longitudinal section a right-angled triangule in *E. neriifolia*, with the spine shield located almost at a right angle from, and close to the floral eye; podarium figuring an equilateral triangle in *E. edulis*, with the spine shield set at the vertex. In other words: The stem of *E. neriifolia* tends to be obscurely pentagonal or nearly terete, but the podaria are sharply upraised and, when crowded, form comparatively conspicuous angles, or wings. The stem of *E. edulis* is more nearly pentagonal, occasionally triangular; its podaria slope gently, forming broad, even crenations; the angles are obscure.

It is believed that although individual variations may occur, the shape of the podaria is reasonably constant on young stems of both species.

[43] Herb. Amb. 4 (1743) 88, *pl. 40.*

(*c*) First peduncle of the cyme (that is, the peduncle below the first dichotomy) terete, and evolute, up to 10 mm long in *E. neriifolia;* clavate, stout, not over 3 to 4 mm long in *E. edulis.*

On account of the length of the first peduncle the cyme of *E. neriifolia* is manifestly pedunculate; that of *E. edulis* manifestly subsessile.

The length of the first peduncle of the cyme is a diagnostic character of the first importance. Although in the succulent *Euphorbia* the peduncles often elongate during anthesis and fructification in these two species, the first peduncle of the cyme almost immediately attains its normal length, practically stopping growth before the female stage of anthesis begins. It is suggested that Indomalayan, Indochinese, and Chinese specimens of species of this group having subsessile or sessile cymes may be suspected of belonging, *ipso facto,* to *E. edulis.*

(*d*) Nectarium (gland) always yellow-green in *E. neriifolia;* always pink to pale brown in *E. edulis.* The inner and outer margins of the nectarium are manifestly lipped in *E. edulis,* and scarcely or not lipped in *E. neriifolia.*

The reddish color of the nectarium sometimes persists on dried cyathia of *E. edulis.* The thin, upraised lips at the margins of the nectarium of the same species are usually present in water-soaked specimens.

(*e*) Stigma scarcely 1 to 1.5 mm long in *E. neriifolia;* 2 to 3 mm long in *E. edulis.*

These differences and the different geographic range are in my opinion adequate to establish *E. edulis* and *E. neriifolia* as distinct species.

Euphorbia edulis is not likely to be confused with either *E. caducifolia* or *E. varians* (*E. Nivulia*). The former is a strongly characterized species [44] with nearly terete stems and very abruptly upraised knoblike podaria. Its spine shield is usually large and armed with well-developed pungent thorns. Its cyathium is barely half as broad as those of *E. neriifolia* and *E. edulis* (that is, not over 3 to 5 mm broad at the mouth). Its leaf is much reduced, in young specimens somewhat narrowly ligulate. *Euphorbia varians* (*E. Nivulia*) has terete stems, pedunculate cymes, and podaria scarcely, if at all, upraised.

[44] Fischer in Kew Bull. (1925) 341.

Genus EUPHORBIA Linnæus

Subgenus TITHYMALUS Persoon

Tithymalus Persoon, Syn. Pl. 2 (1806) 10; *nec alior.*; § *Grandifoliae* Berg., Sukk. Euph. (1907) 34, excl. (*E. drupifera*).

Subsection EUNEFOLIEAE novum [45]

EUPHORBIA EDULIS Lour.

Euphorbia edulis Lour., Fl. Cochin. 1 (1790) 298; ed. (1) 2 (1793) 365 *non* Sessé and Mocino, Pl. Nov. Hisp. 81 (1887); Raeusch., Nom. Bot. (1797) 139; Boiss. in DC. Prodr. (2) 15 (1862) 80; Gagnepain in Lecomte, Fl. Gén. Indo-Ch. 5 (1915) 254; Croizat et Metcalf (discr. emend).

Euphorbia neriifolia auct. *non* L. *sensu* de Cand., Hist. Pl. Gr. (1799) *pl. 46;* Lam., Enc. Méth. 2 (1786) 415; Persoon, Syn. Pl. 2 (1806) 11; Haw., Syn. Pl. Succ. (1812) 130; Colla, Hort. Ripul. (1824) 54; ? Gagnepain in Lecomte, Fl. Gén. Indo-Ch. 5 (1915) 239.

Euphorbia laurifolia Hort. Bot. Panorm. *non* Lam.; Bull. Ort. Bot. Palerm. app. 3 2 (1898) xviii.

Tithymalus aizoides, arborescens, spinosus, caudice angulari, nerii foliis Bonelli, Hort. Rom. 15 (1772) *fig. 28, non* Commel. Prael. Bot. (1703) *pl. 22.*

? Ligularia, Rumph. Herb. Amb. 4 (1743) *pl. 40 (quoad habitum).*

Frutex succulentus, 3- ad 4-gonus, laxe ramosus, ad 4 ad 5 m altus. Foliis carnosulis, enerviis, integerrimis, ad 14 cm longis, 5 cm latis, oblongo-cuneatis, in petiolum crassum circa 1 cm longum abeuntibus. Cymis subsessilibus, pedunculo primario clavato vix 2 ad 3 mm longo, pedunculis secundariis ad 10 mm longis. Cyathio 8 ad 10 mm lato; nectariis nequaquam viridibus, vulgo brunneis 1, roseis, in sicco interdum coccineis, contiguis, 5×2 mm magnis, bene ad margines labiatis; lobis viridibus, late spatulatis, fimbriato-laciniatis, 2×3 mm magnis; bracteis ad cyathium 2, arcte amplectentibus, ovato-truncatis 1. Quadrangulis, mucronatis, dorso carinatis, apice erosodenticulatis. Floribus ♂ ca. 40 in 5 fasciculis bene congregatis, apice purpureis; staminodiis plurimis, profunde laceratis. Flore ♀ incluso, ecalyculato, trigono, 2×2 magno, stipite teretiusculo sub apicem eroso fulto. Stylo 2 mm longo; stigmatibus capitatis, integris, 2 ad 3 mm longis, patentibus. Capsula ignota.

[45] A § *Tekeaneæ* (sphalm. *Tekeanae*) Croiz. [Bull. Jard. Bot. 15 (1938) 119] cymis minoribus, habitu, statura bene discedit; a subsect. *Sudanicæ* subsect. nov. (Typus: *E. sudanica* Chev.) foliis semper integerrimis, aculeis binis, habitatu diversa.

Neoicotypus[46] *Metcalf 18578*, April 16, 1938, Campus Lingnan University Canton "Euphorbia Fl. yellow and red: woody, 4 m high" (icon. phot. specimina sicca, cymae in fluido in herb. Arn. Arb.).

Cymis subsessilibus, nectariis nequaquam viridibus, stigmatibus longiusculis, foliis oblongo-cuneatis breviter petiolatis, podariis saltem sub ramulorum apicem exacte triangularibus ab E. neriifolia optime differt.

[46] *Sensu* Furtado in Gard. Bull. Straits Settl. 9 (1937) 288.

CHIRONOMIDÆ FROM JAPAN (DIPTERA), XI

NEW OR LITTLE-KNOWN MIDGES, WITH SPECIAL REFERENCE TO THE METAMORPHOSES OF TORRENTIAL SPECIES [1]

By Masaaki Tokunaga

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FIVE PLATES

In this paper I am discussing twenty-five chironomid midges, including three tanypodines, one diamesine, seventeen orthocladines, and four chironomines, collected from Honshu and Formosa.

Of these midges, the following five species were found on high altitudes in Formosa: *Spaniotoma nudipennis, S. niitakana, S. truncatocaudata,* and *S. takahashii,* on Mount Niitaka, at an altitude of 3,600 to 3,900 meters; and *Tanytarsus taiwanus,* on Mount Gokan at an altitude of 3,000 meters.

In my previous paper I reported three chironomids collected from hot springs, and at this time I intend to add two other species to the series of thermophilous midges. The chironomids collected are as follows: *Pentaneura okadai,* from Yunomine-Onsen, temperature 29.2° C.; *Chironomus lugubris,* from Unzen-Onsen, temperature 71° to 38° C.; *C. crassiforceps,* from Sozan-Onsen, temperature 38° C.; *Tanytarsus uraiensis,* from Urai-Onsen, temperature unrecorded; and *T. okadai,* from Tsubame-Onsen, temperature 36° C.

The metamorphoses of the following eleven species are also dealt with in this paper: *Anatopynia nebulosa, Chironomus crassiforceps, Heptagyia brevitarsis, Cardiocladius capucinus, Spaniotoma kibunensis, S. kanii, S. tentoriola, S. saxosa, S. suspensa, S. filamentosa,* and *S. intermedia.* The nine last-named species are truely torrential in habitat, and their immature forms are distinguishable by the following key.

Key to the species of torrential midges.

LARVÆ

1. Head with a pair of blunt tubercles; posterior pseudopods with numerous claws which are arranged into several complete rings.
Heptagyia brevitarsis (Tokunaga).

[1] Contribution from the Entomological Laboratory, Kyoto Imperial University, No. 74.

Head without tubercles; posterior pseudopods each with sixteen claws at most ..... 2.
2. Median tooth of mentum very broad, finely serrulate; posterior pseudopods each with only ten claws..... *Cardiocladius capucinus* Zetterstedt.
Median tooth of mentum otherwise; posterior pseudopods with more claws ..... 3.
3. Mandibles each with two simple setæ at base of cutting edge; posterior pseudopods each with fifteen claws..... *Spaniotoma tentoriola* sp. nov.
Mandibles each with one or more plumose setæ at base of cutting edge; posterior pseudopods each with sixteen claws..... 4.
4. Basal tubercles of caudal tufts entirely or partially thickened..... 5.
Basal tubercles of caudal tufts entirely fleshy..... 6.
5. Median tooth not subdivided; basal tubercles of caudal tufts partially thickened on caudal side..... *Spaniotoma suspensa* sp. nov.
Median tooth subdivided; basal tubercles of caudal tufts entirely thickened ..... *Spaniotoma kibunensis* sp. nov.
6. Head black ..... 7.
Head brown or yellow ..... 8.
7. Premandibles spatulate distally; mesal lobe of hypopharynx with simple processes; ventral anal gills tubular..... *Spaniotoma kanii* sp. nov.
Premandibles each with a small pointed projection on distal edge; mesal lobe of hypopharynx with serrulate processes; ventral anal gills constricted ..... *Spaniotoma intermedia* sp. nov.
8. Premandibles slender; mesal lobe of hypopharynx with spatulate processes; anal gills all swollen basally.... *Spaniotoma filamentosa* sp. nov.
Premandibles spatulate distally; mesal lobe of hypopharynx with trichoid processes; anal gills with dorsal pair short, oval, ventral pair tubular. *Spaniotoma saxosa* sp. nov.

PUPÆ

1. Abdominal terga without spinose ridges or patches. *Heptagyia brevitarsis* (Tokunaga).
Abdominal terga with spinose ridges or patches..... 2.
2. First abdominal tergum with spinose ridges. *Cardiocladius capucinus* Zetterstedt.
First abdominal tergum without spinose ridges or patches..... 3.
3. Ultimate ninth abdominal tergum with caudal bristles..... 4.
Ultimate ninth abdominal tergum without caudal bristles..... 6.
4. Thoracic respiratory organs absent..... *Spaniotoma kibunensis* sp. nov.
Thoracic respiratory organs present..... 5.
5. Sixth to eighth abdominal terga with caudal spinose ridges. *Spaniotoma tentoriola* sp. nov.
Sixth to eighth abdominal terga without caudal spinose ridges. *Spaniotoma filamentosa* sp. nov.
6. Thoracic respiratory organ absent..... *Spaniotoma intermedia* sp. nov.
Thoracic respiratory organ present..... 7.
7. Second and third abdominal terga without spinose ridges or patches. *Spaniotoma kanii* sp. nov.
Second and third abdominal terga with spinose ridges or patches..... 8.

8. Eighth abdominal tergum with a spinose patch.
Spaniotoma suspensa sp. nov.
Eighth abdominal tergum without spinose patches.
Spaniotoma saxosa sp. nov.

Biological observations of these torrential midges will be reported in detail in the future by Mr. Tokichi Kani, of Kyoto Imperial University.

The taxonomic system adopted in this paper is mainly that of Dr. F. W. Edwards.(2) The morphological terminology is based on my previous papers. The antennal ratio is the ratio between the length of the ultimate segment and the combined length of the remaining segments, except the scape, and, in the case of the males of the Tanypodinæ, between the combined length of the ultimate two segments and the combined length of the remaining segments, except the scape. The leg ratio is the ratio of the length of the first tarsal segment of the leg to that of the tibia.

Acknowledgments.—I am greatly indebted to Prof. Chukichi Harukawa and Dr. Hachiro Yuasa, with whose kind help this study was made possible. My deepest thanks are also extended to Prof. Yaichiro Okada and Mr. Yuichi Ito, of Tokyo Higher Normal School, Dr. Ryoichi Takahashi, of the Government Research Institute of Formosa, Mr. Tokichi Kani, of Kyoto Imperial University, and to Mr. Kaoru Fujimatsu, of Tohoku Imperial University, for the privilege of retaining the invaluable specimens in our laboratory.

TANYPODINÆ

ANATOPYNIA NEBULOSA Meigen.

Anatopynia nebulosa MEIGEN, Philip. Journ. Sci. 62 (1937) 40, 41; Fauna Nipponica No. 16 (1937) 80–82.

A male fly was reared from a pupa found in a small stream in the botanical garden of Kyoto Imperial University.

Male.—Body about 7 millimeters long, black in ground color. Head entirely black; thorax almost entirely black, slightly pruinose and brown at shoulder parts; postscutellum setigerous on caudomeson; abdomen mainly black, white and hyaline at caudolateral corners of second to seventh terga. Antennæ 15-segmented; antennal ratio about 2.5. Wing comparatively narrow, with anal lobe round; wing markings somewhat more obscure than in female. Haltere white. Legs mainly black; tro-

chanters and femora brownish; tibiæ somewhat brown, broadly at middle; tarsal beards absent; leg ratio about 0.73 in foreleg, 0.59 in middle leg, and 0.61 in hind leg. Hypopygium (Plate 2, fig. 25) black, with styles short, stout, setigerous on inner side.

Pupa.—Length about 10 millimeters; exuviæ brown, semihyaline. Head and thorax without distinct tubercles and bristles. Thoracic respiratory organ (Plate 3, fig. 67) flattened, finely imbricate. Foreleg sheath with a mesal distinct projection at tibial end. Abdominal segments with characteristic markings of spinulous areas and chætotaxy; markings of dark spinulous areas as follows: On dorsal side, first tergum without special dark area; second to seventh terga similar, each provided with a pair of small lateral areas on cephalic part and a large mesal area (Plate 3, fig. 73); eighth tergum without lateral areas, with a large subtriangular mesal area; remaining terga without distinct areas. On ventral side, first sternum without special spinulous areas; second and third sterna with a pair of large lateral subtriangular areas; fourth to seventh sterna each with a large area formed by fusion of paired areas; other sterna without distinct areas. Abdominal chætotaxy as follows: Each tergum typically with five pairs of setigerous tubercles on caudal half and a pair of small setæ on lateral sides; first tergum with four pairs of ordinary setæ on mesal part and two similar setæ on either lateral side; seventh tergum with six swimming hairs on either lateral side in addition to five pairs of setigerous tubercles; eighth tergum with five swimming hairs on either lateral side and only one pair of small mesal ordinary setæ on caudal part; on ventral side, each sternum typically with only two pairs of slender setæ on caudal part and one small seta on either lateral side; first sternum without distinct setæ; second sternum with only one pair of mesal setæ; eighth sternum without ventral setæ. Each swimming paddle of ultimate segment large, elongate, sharply pointed, fringed with delicate hairs on lateral side, finely serrulated apically, with two large isolated setæ on basal part of lateral margin (Plate 3, fig. 87); sheaths of hypopygium comparatively small, not extending caudad beyond caudal incision between swimming paddles.

Specimens.—Alcoholic male and its pupal exuvia; Kitashirakawa, Kyoto, December 6, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected and reared by M. Tokunaga.

PENTANEURA ESAKII sp. nov.

This species was collected at light in summer at Kiso, Honshu.

Male.—Body about 2.2 millimeters long, yellowish white in ground color, with four brown scutal vittæ; abdominal terga of third, fourth, sixth, seventh, and eighth segments mainly dark brown. Head with occipital side pale brown, a brown V-shaped marking on vertex, other parts white. Antenna 15-segmented; scape bicolored, being white on proximal half and pale brown on distal half; flagellum and plumose hairs brown; antennal ratio 0.63 (10.5 + 4: 23). Thorax with four brown distinct scutal vittæ; caudoscutal area with two small brown obscure stripes; scutellum yellowish white; postscutellum brown; pleural side with two brown spots, one on anterior and one on posterior notepisternum. Legs entirely yellowish white. Wing (Plate 1, fig. 1) slightly dark uniformly, without special markings; all veins brown; R_2 distinct; R_3 obscure. Abdomen bicolored; first, second, and fifth terga entirely white; third and fourth terga largely dark brown, each with a pale narrow band on caudal margin; sixth, seventh, and eighth terga uniformly dark brown; ninth tergum pale brown. Hypopygium (Plate 2, fig. 27) white; coxite slender, with a basal pubescent lobe; style slender, finely pubescent basally, with about three delicate setæ, apical spine yellow.

Female.—Body about 1.4 millimeters long; color somewhat paler than in male. Antenna 12-segmented; ultimate segment elongate, with a small apical projection and a terminal seta; proportional length of four distal segments as follows: 13: 12.7: 12.7: 33.5; scape entirely white; antennal ratio about 0.23; proportional length of five segments of maxillary palpus 2: 3: 7: 8: 15. Pleural side of thorax with only one distinct brown spot, posterior pleural spot obscure. Wing (Plate 1, fig. 2) comparatively broad. Legs with strong tibial spurs; spurs of middle tibia distinctly unequal, larger spur fully thrice as long as shorter spur; empodium and pulvilli vestigial; leg ratio about 0.89 in foreleg, 0.94 in middle leg, and 0.76 in hind leg. Abdomen with third and fourth terga obscurely brown; cerci very small, vestigial; spermathecæ three, hyaline, equal, short-oval, each with a short neck region.

Habitat.—Honshu, Japan.

Holotype.—Male; Miure, Otaki-Mura, Nagano Prefecture; August 19, 1937.

Allotopotype.—Female; August 19, 1937.

Paratopotypes.—Females; August 19, 1937.

Type specimens.—Alcoholic; deposited in the entomological laboratory of Kyushu Imperial University; collected by Prof. T. Esaki and Mr. K. Yasumatsu.

This species is closely allied to *P. divisa* Walker, but very easily distinguished by the small value of the male antennal ration and by the presence of middle distinct scutal vittæ in both sexes.

PENTANEURA ESAKIANA sp. nov.

This midge was collected at light at Kiso, Honshu.

Male.—Body about 4.5 millimeters long, snowy white; wing without markings. Head with black eyes. Antenna 15-segmented, with flagellum pale brown; plumose hairs white; ultimate segment with a short apical seta; antennal ratio about 1.62 (29+8:29). Legs without beards; pulvilli absent; relative lengths of legs 67:85:69:35:23:17:9 in foreleg, 73:72:40:18:14:13:7 in middle leg, and 65:96:66:37:27:18:7 in hind leg. Wing closely similar to that of *P. melanops*, with thick hairs spread over entire surface; veins yellow; costa very slightly produced beyond end of R_{4+5}; fork of R_{2+3} complete; R_3 ending beyond middle between ends of R_1 and R_{4+5}. Abdomen almost entirely white; eighth tergum somewhat brown on anterior half; hypopygium with three pubescent projections (Plate 2, fig. 26) between bases of coxites; styles angulated, entirely pubescent.

Habitat.—Honshu, Japan.

Holotype.—Alcoholic male; Miure, Otaki-Mura, Nagano Prefecture; August 19, 1937; deposited in the entomological laboratory, Kyoto Imperial University; collected by Prof. T. Esaki and Mr. K. Yasumatsu.

This midge is very closely allied to *P. melanops* Meigen, but distinctly different in the absence of the thoracic scutal vittæ and in the presence of the three basal projections between the coxites.

DIAMESINÆ

HEPTAGYIA BREVITARSIS (Tokunaga).

Prodiamesa (*Monodiamesa*) *brevitarsis* TOKUNAGA, Philip. Journ. Sci. 59 (1936) 528–530; Fauna Nipponica No. 16 (1937) 42, 43.

On examination of the metamorphosis of this species I am transferring it from *Prodiamesa* to the genus *Heptagyia*. Many larvæ and pupæ of this species were found clinging to rocks at the splash line in a rapid stream at Kibune, Kyoto. I have ob-

tained several imagines from these pupæ and I am confident that they are quite identical with *Prodiamesa brevitarsis* the male of which has been reported in my previous paper.(13)

Female.—Body about 2 millimeters long, black in ground color; thorax very shiny, with small setæ. Head with eyes reniform, widely separated from each other, separation as wide as their vertical lengths; frontal tubercles present, but far smaller than in male; antenna 7-segmented (18:23:15:20:18:18:34); third segment spherical, other distal segments all oval; ultimate segment with several short apical setæ; maxillary palpus with four distinct segments (3:3:6:11). Thorax with pronotum very widely separated at middle, with several setæ on either lateral side; postscutellum hemispherical. Legs dark brown, proportional lengths of segments as follows: 55:34:22:12:7:4.5:8 in foreleg, 40:51:22:11:6.3:3.5:8 in middle leg, and 55:58:30:17:10:5:9 in hind leg. Haltere yellow. Wing (Plate 1, fig. 3) slightly brown by transmitted light, distinctly brown in cell Sc and distal part of cells R_1 and R_3 and along M_{1+2}; veins dark brown; alula with a few marginal setæ; vein R_{2+3} atrophied on distal half or more; stem of M very slender but distinct; M_{3+4} anastomosed with Cu_1 at its inflected point: Cu_1 slightly undulate at distal end. Abdomen black, with short setæ; cerci (Plate 2, fig. 46) somewhat pentagonal, dark brown; spermathecæ (Plate 3, fig. 47) three, spherical, mainly dark brown, pale brown only at basal part, without thickened neck region.

Pupa.—Body length about 2.2 to 2.8 millimeters in male and 3.5 to 3.8 millimeters in female; exuvia dark brown on head, thoracic region, and abdominal end, and almost colorless and hyaline on abdominal region. Head with a pair of blunt tubercles between antennal bases, each of these tubercles with small black seta on frontal side; sheath of antenna mainly dark brown, with apical part hyaline and colorless, with a black minute terminal thorn. Thorax dark brown, entirely, distinctly shagreened; pronotum very widely separated at middle, each lateral half produced laterad, forming a ridge, with about three setæ; scutum with a pair of lateral ridgelike thickenings between bases of wings and respiratory organs; each lateral side with about five setæ near respiratory organ, an isolated seta on dorsocephalic margin, three setæ before wing base, a seta dorsad of wing base, a seta on middorsal part; scutellum with a pair of simple setæ at lateral sides; respiratory organ (Plate 3, fig. 69)

black, triangular, sharply pointed, covered with small delicate hairs and with a gelatinous layer. Abdomen hyaline, clear, almost entirely spinulous; ventral side somewhat darker than dorsal side, especially on posterior segments; abdominal setæ almost simple, small, slender and indistinct. Chætotaxy of abdominal segments as follows: Tergum typically with a pair of small setæ on cephalic part, three pairs on caudal margin, and an isolated seta on either lateral side; pleuron with two setæ on cephalic part and two smaller setæ on caudal part; sternum with three pairs of very small setæ on mesal part; ultimate segment (Plate 3, fig. 88) dark brown, with a pair of small lateral ridges, a pair of minute setæ on dorsal side; each lateral ridge with three hooklike strong setæ; genital sheaths of both sexes prominent; penultimate segment of female with small dark sheaths of valvulæ.

Larva.—Body about 5 to 5.2 millimeters long in full-grown stage; head with blunt tubercles; thorax and abdomen with characteristic markings of cuticular armature. Head black, with a pair of blunt tubercles on vertex; frontal plate without tubercular projections. Antenna (Plate 4, fig. 95) situated on prominent basal erection, consisting of four segments; proximal two segments black; third segment longer than preceding, with spiral ental thickening; ultimate segment conical, minute, hyaline; first segment with a large trichoid sensilla on distal end; second with three black minute thickenings on distal end. Clypeus uniformly thickened; labrum (Plate 4, fig. 116) membranous, with several pairs of simple trichoid and peglike appendages on mesal area, several comblike armatures and about fourteen serrulate hooklike appendages on either side; epipharynx with a pair of prominent premandibles, a Y-shaped thickening, and hooklike and hairlike appendages; premandible (Plate 4, fig. 106) serrated into about eight small teeth, with several accessory setæ on lateral side; Y-shaped thickening consisting of a pair of narrow sclerites which are not fused with each other on the part of stem; membranous area between arms of Y-shaped thickening with five large somewhat spatulate hooklike appendages on mesal area, two finely serrulate hooklets and two simple hooklets along mesal side of each arm of Y-shaped thickening, and four hairlike appendages on distal area. Mandible with five teeth, a hyaline long trichoid projection at base of cutting teeth, about eleven basal setæ arranged radially, in this closely resembling *H. lurida* Garrett, reported by Dr. L. G.

Saunders.(9) Maxilla (Plate 4, fig. 120) consisting of two lobes; lateral lobe with a large disclike palpus, a tuft of hyaline setæ, a long simple and a small branched seta; mesal lobe with several trichoid sensillæ, highly setigerous on distal area. Labium with a large black mentum (Plate 5, fig. 139) which carries seven pairs of lateral teeth and a median tooth, and a pair of simple accessory basal setæ. Hypopharynx (Plate 5, fig. 140) with apical lobe highly spinose, with large hooklike ventral spines, numerous simple apical spines, and two pairs of small sensillæ; dorsal wall highly spinose, with numerous minute simple spinules. Thoracic and abdominal region (Plate 4, fig. 110) dark brown, with characteristic black markings on convex dorsal side, yellowish white on flattened ventral side. Thoracic pseudopod distinctly bilobate, with numerous golden-brown, slender, simple hooklets. Posterior pseudopods large, short, cylindrical, projecting ventrad, each forming a terminal sucking cup, surrounded by five or seven almost complete circles of dark-brown simple claws (Plate 5, fig. 150). Anal gills small, four, three projecting caudad and one cephalad between pseudopods as stated by Dr. L. G. Saunders.(10) Caudal tufts of setæ short, black, each consisting of four simple and two branched setæ, without distinct basal tubercle. Cuticular armature similar to that of Saunders's *H.* sp. A.(10)

Nest case.—Larvæ free-living, without special nest cases. Pupæ enclosed in gelatinous nest cases. Pupal case with double wall; external wall thick, gelatinous, convex dorsad, oval, about 6 to 8 millimeters long and 4 to 7 millimeters wide; internal wall of pupal case very thin, hyaline, parchmentlike, closely and completely surrounding pupal body; larval skin retained on posterior segments of pupa, being enclosed within the parchmentlike sack together with pupa.

Habitat.—Hygropetric, torrential stream; Honshu, Japan.

Allotopotype.—Female; Kibune, Kyoto; February 21, 1937.

Paratopotypes.—Males and females; February 19 and 27, 1937.

Type specimens.—Alcoholic and dry imagines, alcoholic pupæ and larvæ; Kibune, Kyoto; February 2, 1935, and February 19 and 27, 1937; deposited in the entomological laboratory, Kyoto Imperial University; collected by Mr. T. Kani and M. Tokunaga.

The immature stages of the genus have been reported by Dr. L. G. Saunders(9, 10) in detail. The present species is closely allied to his *H. rugosa* in the structures of the larval head, but quite different in the structures of the posterior pseudopods and

the thoracic and abdominal cuticular markings of the larva and the thoracic respiratory organs of the pupa.

ORTHOCLADIINÆ

BRILLIA MODESTA Meigen.

This midge was collected at Kibune, Kyoto, in autumn.

Male.—Body about 3 to 3.2 millimeters long; thoracic ground color pale brown. Head with vertex brown; antenna pale brown, with scape brown; antennal ratio about 1.08 to 1.12; maxillary palpus pale brown, 5-segmented (12:20:75:68:67). Mesothoracic scutum brown, with three vittæ; middle vitta dark brown, reaching caudal margin of scutum; lateral vittæ black; scutellum brown; postscutellum black; pleural and sternal sclerites brown. Legs almost entirely pale brown; middle and hind coxæ brown; proportional lengths of segments of foreleg 49: 60.5:52:25.5:18.5:13.5:7.9, those of hind leg 56:67.5:36.5: 24.5:19.5:12.8:7.5. Wing (Plate 1, fig. 4) with costa produced beyond end of R_{4+5}; r-m long, slightly curved; R_1 about two-thirds of R_{4+5}; fMCu slightly before fR. Haltere white. Abdomen uniformly brown; posterior four or five terga sometimes dark brown; hypopygium (Plate 2, fig. 28) with coxite slender; style basally pubescent, almost straight, with a very long basal projection subequal in length to the style itself; basal lobe of coxite slightly setigerous on ventral side.

Specimens.—Alcoholic males; Kibune, Kyoto; October 16, 1934; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

BRILLIA JAPONICA sp. nov.

This midge is very abundant in Kyoto, especially in spring and autumn.

Male.—Body about 3.2 to 4.3 millimeters long; coloration closely similar to that of *B. longifurca* Kieffer. Head with mouth parts and antennæ brown. Antenna 14-segmented; third and fourth segments transverse, fifth somewhat cylindrical, other distal segments elongated, cylindrical; antennal ratio variable, from 0.7 to 0.97 (mean value, 0.836). Thorax yellowish pale brown; pronotum dark brown at middorsal side; scutum with three dark-brown vittæ; caudoscutal area with two short brown stripes; scutellum brown; postscutellum dark brown; pleural and sternal sclerites dark brown. Legs mainly brown, coxæ of middle and hind legs dark brown; forelegs and hind legs with relative lengths of segments 67:87:68:35:27:19:11

and 52 : 67 : 53 : 26 : 20 : 15 : 9, respectively; foreleg ratio 0.71 to 0.88 (mean value 0.794). Haltere white. Wing with thick macrotrichia spread on entire surface; costa produced beyond end of R_{4+5}; r-m slightly curved; fMCu just before fR. Abdomen yellow in ground color, with brown bands; first tergum with one pair of brown spots, second to fifth terga each with a brown narrow band, other caudal terga mainly brown, very narrowly yellow along caudal margin. Ultimate tergum (Plate 2, fig. 29) with reticular impression of integument; coxite with a long lobe which is pubescent only on ventral side; style bifurcate, lateral lobe about half as long as mesal lobe.

Female.—Body 2.5 to 4.1 millimeters long; color as in male. Antenna 6-segmented (3.5 : 7 : 4 : 4.7 : 4.9 : 5.1). Maxillary palpus 5-segmented (3 : 5 : 13 : 13 : 14). Foreleg ratio 0.77 in mean value. Wing (Plate 1, fig. 5) comparatively broad; vein Cu_1 almost straight; fMCu under middle of r-m. Cercus (Plate 2, fig. 48) highly setigerous, with a long ventral lobe; spermathecæ (Plate 2, fig. 49) two, pear-shaped, yellow.

Habitat.—Honshu, Japan.

Holotype.—Male; Yamashina, Kyoto; November 18, 1935.

Allotopotype.—Female; November 18, 1935.

Paratypes.—Males and females; Kyoto: Hachijo, May 23, 1930; Kibune, October 2 and 16, 1930 and 1934, and April 22, 1932; Kitashirakawa, November 3, 13, 15, and 22, 1935; Yamashina, November 18, 1935.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

The present species is very closely allied to *B. longifurca* Kieffer, but in the allied species the antennal ratio is very large, being 2.5, and the male hypopygium is provided with longer and more distinctly curved styles.

METRIOCNEMUS (PARAMETRIOCNEMUS) STYLATUS Kieffer.

The males were swarming on still water in spring.

Male.—Body about 3.4 millimeters long, wing 2.4; ground color yellow. Head mainly yellowish brown; occipital region dark brown; eyes bare, distinctly extending dorsad. Antenna 14-segmented, with flagellum brown, scape dark brown; ultimate segment irregularly swollen on apical part, with four long preapical sensory setæ (Plate 1, fig. 24); antennal ratio about 1.07; mouth parts yellowish brown; palpus 5-segmented (2 : 3 : 7 : 9 : 13). Thorax yellow in ground color; pronotum brown at

middle on either side; scutum with four distinct dark-brown vittæ; caudoscutal area brown; scutellum with black marginal ring; postscutellum black; pleural sclerites brown; sternal side dark brown. Legs brown, with forecoxæ yellow, middle and hind coxæ brown; proportional lengths of segments of fore and hind legs 51:59:43:24:16:11:6 and 52:62:38:19:15:7.5:6.5, respectively; foretibiæ each with a long spur; middle tibiæ each with two small spurs; hind tibiæ each with a long and a minute spur; no tarsal spurs; claws each with two minute apical teeth; empodium slender, shorter than claws; pulvilli vestigial. Wing (Plate 1, fig. 6) with thick decumbent macrotrichia; squama fringed, with about eight setæ on basal half; veins yellow; costa produced beyond end of R_{4+5}; R_1 about half as long as R_{4+5}; R_{2+3} extending closely along R_{4+5}; r-m vertical; fMCu slightly beyond fR; Cu_1 slightly undulate. Haltere white. Abdominal terga largely brown, very obscurely pale brown along caudal margin of each tergum. Hypopygium (Plate 2, fig. 30) with setigerous anal point which is hyaline only on bare apical part; coxite with blunt mesal lobe; style with distinct dorsal keel, apical spine yellow.

Specimens.—Alcoholic males; Nagaoka, Kyoto; April 5, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

CARDIOCLADIUS CAPUCINUS Zetterstedt.

This species is often found in a rapid clear stream. The pupæ are found in white oval nest cases on stones.

Male.—Body about 3.2 millimeters long, almost entirely black; frontal aspect of head dark brown, pleural membranes brown or dark brown, haltere white. Antenna 15-segmented, without apical setæ; antennal ratio about 1.48. Thorax entirely black. Legs with tarsal spurs on three proximal segments of all legs; claws slightly spatulate and finely pectinate at tip; no pulvilli; relative lengths of segments of fore, middle, and hind legs 54:69:54:30:17:5.5:9, 62:66:32:22:13:5:8, and 70:83:45:26:17:5.5:10, respectively; fourth tarsal segments (Plate 1, fig. 22) of all legs distinctly flattened, shorter than fifth. Wing (Plate 1, fig. 7) broad, with anal lobe round, without black spot on r-m, vein R_1 about half length of R_{4+5}, R_{2+3} ending before middle between ends of R_1 and R_{4+5}, fMCu just beyond fR, Cu_1 almost straight. Abdomen almost entirely black. Hypopygium (Plate 2, fig. 31) with ultimate tergum small, bilobate caudad, setigerous only on caudal margin, without anal point; coxite

elongated, with a distinct basal lobe; style with dorsal ridge slightly developed.

Female.—Body as large as male, somewhat paler than in male; frontal aspect of head pale brown; antenna mainly pale brown, with ultimate segment black; pronotum brown; scutum black, with shoulder parts brown; scutellum brown; postscutellum and pleural and sternal sclerites black; abdominal terga of first and second segments pale brown, other terga black. Antenna 7-segmented (18:20:15:16:18:18:58); ultimate segment with only one apical seta. Legs with claws simple; proportional lengths of segments 54:69:54:30:17:5.5:9 in foreleg, 62:66:32:22:13:5:8 in middle leg, and 70:83:45:26:17:5.5:10 in hind leg. Wing with anal lobe almost right-angled, R_1 shorter than half of R_{4+5}. Cercus (Plate 2, fig. 51) black; spermathecæ (Plate 2, fig. 52) somewhat pyriform, black, with hyaline neck part; fingerlike projection (Plate 2, fig. 50) of ninth segment longer than cerci. Other structures mainly as in male.

Pupa.—Body about 3.9 to 4.5 millimeters long, brown on head, thorax, and abdominal end. Head with papilliform frontal tubercles, with five very small papillæ: one on postclypeal region, two on preclypeal region, and two on scapes of antennæ, without distinct setæ. Thorax without special respiratory organs, distinctly shagreened on caudoscutal area and mesal area of postscutellum, without distinct tubercles. Abdominal dorsal side brown, extensively and finely spinulous; ventral side hyaline, smooth. Abdominal chætotaxy as follows: tergum with long *a*, *b*, and *e* and small *c* and *d* setæ, sternum with small *i* and *l* and minute *j* and *k* setæ, and either lateral side with long dorsal *g* setæ, and minute ventral *n* and two *o* setæ; eighth segment without dorsal *a*, ventral *i*, *j*, and *k*, and all lateral setæ; ultimate segment with only three strong setæ on caudal part of either lateral side. Characteristic arrangement of spinous areas as follows: thickly spinous transverse bands composed of black very long spines on anterior and posterior margins of first tergum and posterior margins of following seven terga; strongly shagreened transverse patches composed of black small spines on middle parts of second to seventh terga and a small similar patch caudad of caudal spinose band of seventh tergum; spinose oval patches composed of very small spines on caudolateral parts from second to seventh terga (Plate 3, figs. 75, 83, and 90). Ultimate segment of male with genital sheaths long, upcurved;

ultimate segment of female with short, papilliform genital sheaths which are visible in dorsal aspect.

Larva.—Body of full-grown form about 6.5 millimeters long, dark green. Head with frontal plate, margin of mouth opening, and occipital margin brown, other parts yellow; eye spots each consisting of two masses of pigment, of which the anterior mass is found in a round yellow area. Antenna (Plate 4, fig. 96) 5-segmented, black. Labrum (Plate 4, fig. 112) with short, simple, trichoid appendages. Epipharynx (Plate 4, fig. 113) with triple distomesal teeth, two pairs of large and two pairs of slender lateral teeth, five pairs of small lateral spines between arms of U-shaped thickening, basal plate elongate; premandible (Plate 4, fig. 105) nonserrate, spatulate on distal part. Mandible with five small cutting teeth, a long plumose hair which is very finely serrulate. Maxilla (Plate 4, fig. 124) very thickly fringed with various spines; palpus subdivided into two semicircular discs. Mentum (Plate 5, fig. 130) with a very broad median tooth which is very finely serrulate on distal margin, five pairs of lateral teeth small, basal setæ simple and single. Hypopharynx (Plate 5, fig. 141) fringed with long simple and serrulate spines, median lobe with four pairs of large and several small comblike scales, dorsal side with various small scalelike projections. Anterior pseudopod with claws arranged into about ten transverse lines; claws of basal seven lines very small, simple or pectinate, those of distal three lines very strong and simple; ventral side of pseudopod spinulose with very fine double and triple spinules arranged into about five transverse lines (Plate 5, fig. 154). Posterior pseudopod with ten large, strongly curved claws. Caudal tuft of setæ consisting of three long and two longer black setæ grown on a short dark-brown basal tubercle. Anal gills similar to each other, elongated, oval. Abdominal ventral and lateral sides often indigo blue due to subcutaneous pigment.

Nest case.—Larvæ free-living, without nest cases. Pupal cases white, oval, about 8 to 10 millimeters long and 4 to 6 wide.

Habitat.—Rapid stream.

Specimens.—Alcoholic imagines, pupæ, and larvæ; Kibune and Nishigamo, Kyoto; January, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected by Mr. T. Kani.

The imagines of the Japanese specimens are somewhat different from those of the European in the possession of a shiny scutum and pale-brown abdominal base of the female. Immature

stages are very closely similar to those of *C. fuscus* Kieffer reported by Dr. L. G. Saunders(8) and Dr. A. Thienemann;(11) the pupal form, however, is distinctly different from *C. fuscus* in the arrangement of shagreened patches which are discontinuous in the allied species, being separated into four small patches.

CARDIOCLADIUS FUSCUS Kieffer.

Two females were collected at a light at Kiso in summer.

Female.—Body about 2.8 millimeters long, black in ground color. Head brown or dark brown, with mouth parts dark brown. Antenna with scape yellowish brown, flagellum dark brown, 7-segmented (13 : 18 : 13.5 : 13 : 14.5 : 16.5 : 51) ; ultimate segment with only one apical seta. Palpus black, 5-segmented (2 : 3.5 : 9 : 13 : 19), third segment distinctly thickened. Pronotum yellow; scutum somewhat shiny, with three black subconfluent vittæ which are obscurely separated by dark-brown stripes; shoulder parts and lateral margins of scutum yellow; postscutellum black; scutellum and pleural and sternal sclerites brown; pleural membranes yellow. Legs mainly dark brown or black; procoxa and bases of all femora yellow; trochanters of all legs yellowish brown; fourth tarsal segments of all legs (Plate 1, fig. 23) distinctly flattened. Proportional lengths of segments of legs 56 : 72 : 52 : 27 : 18 : 5.5 : 8 in foreleg, 62 : 63 : 30 : 19 : 13 : 5 : 8 in middle leg, and 65 : 75 : 43 : 24 : 16 : 5.5 : 8.2 in hind leg. Haltere white. Wing (Plate 1, fig. 8) with veins brown, a dark stripe along caudal margin of M_{1+2}, R_1 shorter than half of R_{4+5}. Abdomen yellow on two anterior segments, black on other segments.

Specimens.—Alcoholic females; Miure, Nagano Prefecture; August 19, 1937; deposited in the entomological laboratory, Kyoto Imperial University; collected by Prof. T. Esaki and Mr. K. Yasumatsu.

CARDIOCLADIUS ESAKII sp. nov.

This species was collected at a light at Kiso.

Female.—Body about 3.3 millimeters long, mainly black. Head dark brown, with palpus black; antenna with scape brown, flagellum black, 7-segmented (16 : 20 : 12 : 15 : 16 : 16 : 53). Thoracic coloration almost as in *C. capucinus*. Legs with proportional lengths of segments 60 : 76 : 55 : 29 : 19 : 5 : 9 in foreleg, 68 : 70 : 32 : 21 : 14 : 5 : 8.5 in middle leg, and 72 : 83 : 48 : 26 : 17 : 5 : 9 in hind leg; fourth tarsal segments (Plate 1, fig. 21) moderately flattened, being intermediate between those of two

preceding species. Abdomen with first tergum dark brown, other terga black, pleural and sternal sides mottled with indigo black.

Habitat.—Honshu, Japan.

Holotype.—Female; Miure, Nagano Prefecture; August 19, 1937; deposited in the entomological laboratory, Kyoto Imperial University; collected by Prof. T. Esaki and Mr. K. Yasumatsu.

This species is intermediate between *C. fuscus* Kieffer and *C. capucinus* Zetterstedt in coloration and shape of penultimate tarsal segments.

SPANIOTOMA (SMITTIA) NUDIPENNIS Goetghebuer.

This species was found at Mount Niitaka, Formosa.

Male.—Body about 2 millimeters long, black in ground color. Head black, with eyes very finely pubescent, mouth parts somewhat brownish; antenna dark brown, 14-segmented, very slightly swollen apically, with apical pubescence; antennal ratio about 1; intermediate flagellar segments from fifth to thirteenth cylindrical. Thorax velvet black; scutellum somewhat brown. Legs dark brown, with long suberect setæ besides small setæ; tibial spurs long; no pulvilli; segments of legs showing proportional lengths 29:36:18:12:8:5:4 in foreleg, 32:32:14:8.5:6:4:3.7 in middle leg, and 34:36:20:11:9:5:4 in hind leg. Haltere dark brown. Wing (Plate 1, fig. 9) milky white; costa very distinctly produced beyond end of R_{4+5}, R_{4+5} ending before level of end of M_{3+4}. Abdomen black, sometimes brownish; hypopygium (Plate 2, fig. 32) with very slender anal point; coxite with small mesal thickened lobe; style entirely pubescent, with dorsal ridge and preapical incision.

Specimens.—Alcoholic males; Mount Niitaka, Formosa; August 29, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected by Dr. R. Takahashi.

SPANIOTOMA (SMITTIA) NIITAKANA sp. nov.

This minute species was collected at Mount Niitaka, Formosa.

Male.—Body about 2 millimeters long, deeply black, darker than *S. nudipennis* Goetghebuer. Head with eyes pubescent. Antenna 14-segmented; ultimate segment not distinctly clavate, pubescent on apical one-third of nonplumose area, with an apical seta, and two preapical sensory setæ; antennal ratio about 2.1; intermediate flagellar segments very short and transverse. Maxillary palpus with five segments (7:18:51:42:46). Pronotum visible in dorsal aspect. Haltere black. Wing (Plate 1, fig. 10) milky white with black squama; vein R_1 about half as long as

R_{4+5}; R_{2+3} ending before middle between ends of R_1 and R_{4+5}; costa slightly produced; Cu_1 distinctly bent. Legs also black, without pulvilli; proportional lengths of segments of foreleg 40:48:25:15:10:6:5, of middle leg 44:45:19:11:8:5:5, and of hind leg 46:51:27:15:11:6:5.8. Abdomen also entirely black; hypopygium (Place 2, fig. 33) with a sharp anal point; coxite with a minute setigerous basal lobe; style with an apical projection and a yellow preapical spine.

Habitat.—Mountain region; Formosa.

Holotype.—Alcoholic male; Mount Niitaka, Formosa: August 24, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected by Dr. R. Takahashi.

This species is somewhat related to *S.* (*S.*) *aterrima* Meigen, but in the related species the anal lobe of the wing is obtuse, the eyes are more thickly pubescent, and the hypopygium is provided with specific styles, highly differing from the present species. *S.* (*S.*) *pratorum* Goetghebuer is also somewhat related to the present species, but is easily distinguished by the following characters: the antennal ratio is about 1.5, the eyes are bare, and the style of the male carries two apical spines. An undetermined species of the subgenus *Smittia* (sp. inc. no. 2) reported by Edwards(2) is most closely allied to the present species in the shape of the male hypopygium, and very probably identical with it.

SPANIOTOMA (SMITTIA) TRUNCATOCAUDATA sp. nov.

This very minute midge was also collected at Mount Niitaka, Formosa.

Male.—Body about 1.7 millimeters long; ground color dark brown; haltere black; wing milky white. Head with eyes bare. Antenna black, with dark plumose hairs; ultimate fourteenth segment gradually swollen apically, thickly pubescent with small stiff microtrichia on its entire length, with two apical setæ, subequal in length to nine preceding segments put together; flagellar segments from third to fifth transverse, lengths of sixth and seventh segments subequal to widths, remaining intermediate segments cylindrical; antennal ratio about 0.73. Frontoclypeus with four setæ; maxillary palpus 5-segmented (6:14:21:25:30), pale brown. Thorax dark brown; pronotum invisible in dorsal aspect; scutum with two lines of pale spots at bases of setæ along pseudosutural foveæ. Haltere black. Wing (Plate 1, fig. 11) milky white, with squama not black; costa slightly produced; R_{2+3} atrophied before costal margin; Cu_1 almost straight.

Legs with coxæ dark brown, other segments pale brown; tarsal spurs obscure; tibial spurs of middle leg extremely small; no pulvilli; fourth tarsal segments of all legs shorter than fifth (21:25 in foreleg, 24:19 in middle leg, and 25:28 in hind leg), but not flattened. Relative lengths of segments of legs 26:32:13:6:5:3.5:4 in foreleg, 27:29:12:6:4:3:3.7 in middle leg, and 29:32:19:9:7:4:5 in hind leg. Abdomen dark brown or brown, with a pale middorsal line throughout entire length. Hypopygium (Plate 2, fig. 34) with ultimate tergum without anal point, setigerous with small stiff setæ on caudal margin; coxite with a large blunt setigerous, basal lobe; style with a thickened preapical dorsal ridge and a yellow apical spine.

Habitat.—Mountain region; Formosa.

Holotype.—Alcoholic male; Mount Niitaka, Formosa; August 24, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected by Dr. R. Takahashi.

This species somewhat resembles *S.* (*S.*) *albipennis* Goetghebuer; the allied species, however, is highly different in the following structures: antennæ with white or gray plumose hairs, antennal ratio larger than 1, vein R_{4+5} shorter, ending above middle of Cu_1, and ultimate tergum with a short anal point.

SPANIOTOMA (EUKIEFFERIELLA) TAKAHASHII sp. nov.

This very minute black species was found at Mount Niitaka, Formosa.

Male.—Body about 1.1 to 1.3 millimeters long, largely velvet black. Head black, with mouth parts and antennæ pale brown, plumose hairs yellowish brown; eyes oval, bare, very widely separated from each other; frontoclypeus with six setæ. Antenna 14-segmented, slightly clavate apically, with apical pubescence, without terminal setæ; ultimate segment shorter than five preceding segments taken together (54:60); intermediate flagellar segments mainly cylindrical; antennal ratio very small, about 0.4. Palpus 5-segmented (6:9:12:13:20). Thorax velvet black; scutellum somewhat brownish; pleural membranes pale brown; sternal and pleural sclerites dark brown; pronotum highly reduced, completely invisible in dorsal aspect. Legs with coxæ brown; femora and tibiæ pale brown; tarsi whitish; middle and hind tibiæ each with two strong preapical bristles besides the two spurs; four proximal tarsal segments of all legs each with an apical spur; no pulvilli; fourth tarsal segment as long as or shorter than fifth (12:16 in foreleg, 14:16 in middle leg, and 15:16 in hind leg); second and third tarsal segments

of hind leg subequal in length (41:41). Proportional lengths of segments of legs 18:21:10.5:4.5:4:2:2.5 in foreleg, 21:24:10.5:6:4.5:2.3:2.5 in middle leg, and 20:23.5:11:6.5:6.5:2.4:2.5 in hind leg. Wing (Plate 1, fig. 12) about 0.9 to 1 millimeter long, slightly milky white; veins almost hyaline; costa very short; R_1 about half as long as R_{4+5}; R_{2+3} extending closely along R_{4+5}; R_{4+5} ending at level of end of Cu_1; fMCu beyond end of R_1; M_{1+2} obscure on proximal part; M_{3+4} and Cu_1 atrophied before wing margin; squama quite bare. Haltere white. Abdomen brown or dark brown; hypopygium (Plate 2, fig. 35) with ultimate tergum bare; anal point blunt, setigerous at base, with thickened end; coxite without basal lobe; style with a small thickened ridge on apical part.

Habitat.—Mountain region; Formosa.

Holotype.—Male; Mount Niitaka, Formosa; August 23, 1936.

Paratopotypes.—Males; August 23, 1936.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University; collected by Dr. R. Takahashi.

The present species is somewhat related to *S.* (*E.*) *coronata* Edwards and *S.* (*E.*) *camptophleps* Edwards. They are, however, easily distinguished by the following characters: In the former the antenna is provided with pubescence only at the extreme tip and the coxite of the hypopygium carries a square mesal lobe, and in the latter the antenna is provided with dark plumose hairs, the black thoracic vittæ are separated from each other by yellow stripes along foveæ, and the wing vein Cu_1 is distinctly bent and the costa produced beyond the end of R_{4+5}.

SPANIOTOMA (ORTHOCLADIUS) KANII sp. nov.

This species is common in a rapid stream in winter in Kyoto. The immature stages are found in gelatinous nest cases built on a stone in a torrent.

Male.—Body about 3.5 to 3.8 millimeters long, dark brown or black in ground color. Haltere yellow. Wing milky white. Head entirely dark brown, eyes bare. Antenna 14-segmented, with plumose hairs black, without apical setæ; antennal ratio 1.5 to 1.76. Palpus with four distinct segments (5:8:8:11.2). Thorax shiny, black; pronotum black; scutum with two lines of distinct pale spots at bases of setæ arranged along foveæ; scutellum highly setigerous, pale brown, with a black ring; postscutellum black; supra-alar setæ six or seven. Legs with coxæ black, other segments entirely dark brown; claws slightly spatu-

late and finely serrulate at tip; empodium very small; no pulvilli; apical tarsal spurs on two proximal segments of middle and hind legs. Foreleg ratio 0.76 to 0.79. Wing (Plate 1, fig. 13) slightly brown by transmitted light, with a prominent anal angle; Cu_1 slightly sinuous on distal part. Abdominal dorsal side dark brown, ventral side brown; hypopygium (Plate 2, fig. 36) black, with a setigerous anal point; coxite slender, with a mesal projection and a shallow concavity just beyond this projection; style with a large dorsal thickened ridge.

Female.—Body about 2.9 to 3.1 millimeters long, ground color yellow. Wing strongly milky white. Head with vertex dark brown, frontal aspect between eyes yellow; clypeus and labella pale brown. Antenna 6-segmented (4:5:2.5:3:3.5:8); scape and basal half of second segment yellow, other segments entirely pale brown; ultimate segment with only one apical seta; antennal ratio 0.57 to 0.67. Palpus dark brown, with four distinct segments (3:7:7:11). Thorax extensively yellow; scutum with three black distinct vittæ; scutellum yellow, with a black marginal ring; notepisternal sclerites with dark clouds; sternepisternum with a black stripe between bases of two coxæ on either side; sternal side black, with a yellow midsternal stripe. Legs with coxæ brown, trochanters yellow; in foreleg, femoral base yellow and other parts dark brown; in middle leg, femur mainly yellow and dark brown only at distal end; in hind leg, femur uniformly brown or dark brown; tibiæ and tarsi of all legs entirely dark brown; claws simple; foreleg ratio about 0.73 to 0.75; two distal segments of middle leg subequal in lengths to each other, but in other legs fourth somewhat longer than fifth. Wing (Plate 1, fig. 14) with basal area somewhat yellowish, and apical margin darkly fumose. Abdomen mainly yellow, each tergum with a rhombic dark-brown cloud; cercus (Plate 2, fig. 53) yellow, with a ventral projection black at tip; spermathecæ (Plate 2, fig. 54) two, unequal, mainly brown, with basal part pale brown, neck region also brown. Other structures mainly as in male.

Pupa.—Body 2.3 to 3.5 millimeters long; exuviæ brown on head, thorax, and genital sheaths, pale brown on abdominal dorsal side and hyaline on ventral side; setæ of thorax and abdomen brown. Head with a pair of very small frontal tubercles, without distinct setæ. Thoracic respiratory organ (Plate 3, fig. 68) somewhat oval, white, smooth, membranous. Chætotaxy of abdomen: Tergum typically (Plate 3, fig. 76) with five pairs of

small setæ (*a, b, c, d,* and *e*); sternum with four pairs of small setæ (*i, j, k,* and *l*); either lateral side with three slender setæ (*g, n,* and *o*); setæ *f, h,* and *m* obscure or absent; lateral swimming hairs absent; first and second terga without setæ *d;* first sternum without distinct setæ; eighth segment without dorsal setæ *a, b,* and *c,* and ventral setæ *i, j, k,* and *l;* ultimate segment (Plate 3, figs. 86 and 91) with a pair of small triangular caudolateral expansions which are larger in male than in female, and with two setæ on each expansion; male genital sheaths very large, portion beyond ultimate tergum far longer than ultimate tergum itself; female genital sheaths short, portion beyond caudal tergum about one-third as long as ultimate segment. Abdominal terga from fourth to ninth and sterna from second to seventh each with a triangular very finely spinulous area on anterior part. Terga from fourth to eighth each with a characteristic short caudal ridge of small spines; this spinulose ridge about one-third of tergal width, consisting of two or three transverse lines of various numbers of spines of which about forty are on the fourth tergum, forty-six on the fifth, thirty-five on the sixth, twenty-three on the seventh, and twenty-four on the eighth segment; these spines black on proximal part and hyaline on distal end.

Larva.—Body about 4.5 to 5 millimeters long in the full-grown stage, yellowish green in life. Head extensively yellow, with eye spots, mentum, mandibles, and occipital margin black. Each eye spot consisting of anterior small reniform and posterior large rhombic pigment mass. Antenna (Plate 4, fig. 104) 5-segmented. Labrum (Plate 4, fig. 114) with a pair of distomedian two-branched appendages on a common plate and many simple hooklike spines; epipharynx with a median strong hooklike appendage and three pairs of strong, one pair of very large, and two pairs of small similar appendages along U-sclerite; first median appendage with three ridges; premandible with a large cutting edge. Mandible with five teeth, a short hyaline projection on base of cutting edge, a hyaline plumose seta on mesal side, and two simple setæ on lateral side. Maxilla (Plate 4, fig. 121) consisting of a large mesal and a small lateral lobe; former lobe with many trichoid projections and several peglike sensillæ; latter lobe with a short maxillary palpus and a few trichoid projections. Mentum (Plate 5, fig. 131) with three broad median teeth, mesal tooth sometimes slightly concave on distal margins, and five or six teeth at either side; setæ of

mentum simple. Hypopharynx (Plate 5, fig. 142) fringed with many hyaline trichoid projections, with four pairs of brown peglike sensory organs, and a hyaline mesal lobe; the mesal lobe quite characteristic in structure for the species, being branched into many simple trichoid projections; dorsal wall of hypopharynx with many hyaline spines, growing inwardly. Thoracic pseudopod with yellow serrulate claws arranged into about fifteen transverse lines (Plate 5, fig. 157); posterior pseudopod with fifteen large, black, simple claws; caudal tuft of setæ consisting of a small fleshy tubercle and six long setæ; anal gills hyaline, unequal; dorsal gills oval, ventral gills slender and tubular.

Nest case.—Hyaline, gelatinous, usually dusty with diatoms on surface, oval; cases of full-grown larvæ and pupæ about 8 to 10 millimeters long, 4 to 5 wide, 3 to 4 high, closely applied on surface of stone. Both larval and pupal cases similar in shape.

Habitat.—Torrential stream; Honshu, Japan.

Holotype.—Male; Nishigamo, Kyoto; January, 1936.

Allotopotype.—Female; January, 1936.

Paratypes.—Males and females; Kyoto: Nishigamo, November 23, 1935, and January, 1936; Hiiragino, November, 1935; Kibune, February, 1936.

Type specimens.—Alcoholic imagines, pupæ and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by Mr. T. Kani and M. Tokunaga.

Allied species may be *S.* (*O.*) *nivosus* Kieffer, *S.* (*O.*) *atriploma* Kieffer, *S.* (*O.*) *oblidens* Walker, and *S.* (*O.*) *thienemanni* Kieffer, which, however, differ from the present species in the following points; In the first allied species fifth tarsal segments of middle leg longer than fourth, these two segments in hind leg equal in length; in the second and third species the male antennal ratio is about 2, and the male hypopygium is provided with a characteristic mesal lobe; in the fourth species the male is provided with three distinctly separated dorsal vittæ on the mesoscutum.

SPANIOTOMA (ORTHOCLADIUS) KIBUNENSIS sp. nov.

This midge is very common along a rapid stream at Kibune, Kyoto, in the winter season. The immature forms are found in gelatinous nest cases closely adhering to the surface of stones at the splashline of clear streams.

Male.—Imagines extruded from mature pupæ about 3.7 millimeters long, almost entirely dark brown. Head with eyes bare; antenna 14-segmented; antennal ratio 1.12; palpus 5-segmented

(10:14:33:44:66). Legs with tarsal spurs on two proximal segments of middle and hind tarsi; all legs each with only one tibial spur; claws finely serrulate at tip, each with three strong basal setæ; empodium as long as claws; no pulvilli; relative lengths of segments of legs 34:42:30:21:17:13.5:8 in foreleg, 41:42:21:15:12:9:7 in middle leg, and 44:50:29:19:17:11:8 in hind leg. Hypopygium without anal point; ultimate tergum subdivided into two setigerous hemitergites; coxite with a mesal lobe which is very similar to that of *S.* (*O.*) *kanii*.

Female.—Ground color brown. Antenna 6-segmented 18:26:16:19:22:46); ultimate segment with only two apical setæ; intermediate flagellar segments cylindrical or oval; palpus 5-segmented (13:18:33:42:65). Legs with proportional lengths of segments 38:48:32:22:17:14:9 in foreleg, 42:46:22:14:11:9:8 in middle leg, and 50:56:29:21:16:11:9 in hind leg; claws simple. Spermathecæ (Plate 2, fig. 55) two, spherical, brown, their basal parts hyaline; cerci (Plate 3, fig. 56) earlike.

Pupa.—Body 3 to 4 millimeters long. Exuviæ dark brown on head, thorax, and ultimate segment, brown on abdominal dorsal side, hyaline on ventral side. Head with two blunt frontal tubercles; frontoclypeal region with three small papilliform tubercles; antennal sheaths each with a ring of minute dots at base. Thorax without respiratory organs, almost entirely smooth; distinct setæ arranged on lateral half of thorax as follows: Two setæ on pronotum, two setæ on anterior margin of scutum, three setæ on laterocephalic margin of scutum, one seta before wing base, and one seta on middle part of scutum. Abdominal dorsal side almost entirely thickly spinulose, each tergum with a dark triangular area on anterior half and a dark narrow band before caudal margin; sternal side without spinulose areas. Chætotaxy: Dorsal side with five pairs of simple setæ (*a* to *e*), seta *e* large, *b* and *c* small; pleural side with six setæ (*g*, *h*, *n*, o_1, and o_2), seta *n* double, o_2 very fine and curly; sternal side with four pairs of simple setæ (*e* to *i*), setæ *i* and *k* large, seta *j* small; from sixth to seventh caudal segments with pleural setæ *g* and *h* not widely separated; eighth segment without dark, large, anterior dorsal area and with only one pair of dorsal setæ *e*, two pairs of ventral setæ *j* and *k*, and one strong lateral bristle, three slender lateral setæ, and one delicate curly seta on either laterocaudal corner. Terga from fourth to fifth (Plate 3, fig. 78) each with a specific caudal ridge consisting of black upcurved hooklets which are arranged in a line

along almost entire length of caudal margin; ultimate tergum (Plate 4, fig. 92) with two hemicircular laterocaudal expansions and three long, black, curved bristles on each expansion; male genital sheaths distinctly extending caudad, straight beyond caudal expansions, and female genital sheaths slightly beyond caudal expansions of ultimate tergum.

Larva.—Body about 3.5 to 5 millimeters long, indigo blue in life. Head oval, almost entirely black; eye spot consisting of a small round and a large reniform pigment mass on a yellow circular area. Antenna (Plate 4, fig. 103) 5-segmented; trichoid organ of first segment very long, fully as long as four distal segments taken together. Labrum closely similar to that of *Cardiocladius capucinus* Zetterstedt, with simple trichoid appendages, without bifurcate appendages; epipharynx (Plate 4, fig. 115) with five large hooklike projections between arms of U-shaped chitinization, and a large elongated median plate; mandible also as in *C. capucinus;* premandible (Plate 4, fig. 107) squarely spatulate at end; maxilla (Plate 4, fig. 123) with prominent palpus and several plumose setæ in addition to ordinary simple setæ and spines. Mentum (Plate 5, fig. 132) with five pairs of lateral teeth, a broad subdivided median tooth, and a pair of simple basal setæ. Hypopharynx (Plate 5, fig. 144) with two pairs of mesal comblike appendages, three pairs of lateral scalelike processes, and numerous marginal setæ, its dorsal wall with many small thornlike and comblike processes. Anterior pseudopod with numerous, very small, simple, serrate claws arranged into six transverse lines; large strongly curved claws arranged in a line and long slightly curved claws arranged into three lines at end of pseudopods, these claws (Plate 5, fig. 156) all golden yellow; posterior pseudopod with four small and twelve large black claws. Caudal tuft of setæ consisting of seven long brown setæ on a short chitinized tubercle.

Nest case.—Gelatinous, hyaline; in shape and size closely similar to *S.* (*O.*) *kanii;* one small respiratory opening on either end.

Habitat.—Hygropetric; Honshu, Japan.

Holotype.—Male; Kibune, Kyoto; February 27, 1937.

Allotopotype.—Female; February 27, 1937.

Paratopotypes.—Males and females; February 27, 1937.

Type specimens.—Alcoholic; imagines extruded from mature pupæ, and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

This midge is very similar to *S.* (*O.*) *kanii* in the structures of imagines. The allied species, however, is distinctly different in the presence af the anal point of the male hypopygium. The immature forms of the present species, especially the pupæ, are highly characteristic in the structures of the abdominal terga, being very easily distinguished from all other known species.

SPANIOTOMA (ORTHOCLADIUS) TENTORIOLA sp. nov.

This species is commonly found in rapid clear streams. The young larvæ are not found in nest cases, free-living on the surface of stones, and the old prepupal and pupal forms are always found in white cocoonlike nest cases.

Male.—Imago taken out from mature pupa 2.7 to 3 millimeters long, almost entirely black. Head with eyes bare; antenna 14-segmented, with antennal ratio about 1.3. Thorax with scutellum brown. Legs without tarsal spurs; pulvilli large; tibial spurs of middle leg two, equally very small; ultimate tarsal segments of all legs slightly compressed laterally; claws finely bifid at tip. Relative lengths of segments of foreleg 11.3 : 13.1 : 11.2 : 7.6 : 5 : 3.5 : 2.3, those of hind leg 13.2 : 16 : 8.9 : 6.3 : 4.2 : 2.4 : 2. Squama of wing fringed with several distinct setæ; fMCu far beyond r-m; R_{2+3} separately ending from R_1 and R_{4+5}; 1A extending far beyond fMCu. Hypopygium (Plate 2, fig. 37) without anal point; coxite swollen ventrad on its basal half, with a mesal triangular lobe; style slender, with a distinct canal on its mesal side, a small thickened ridge only at distal part.

Female.—Imago extruded from mature pupa about 2.8 to 3.2 millimeters long, uniformly dark brown. Head with antenna 6-segmented (12 : 28 : 17.5 : 21 : 23 : 36), with two apical setæ; intermediate flagellar segments with distinct neck region and two short, strong, trichoid sensillæ. Proportional lengths of segments of fore and hind legs as follows: 11.6 : 14.4 : 10.5 : 7.5 : 5.5 : 2.9 : 2.3 and 14.8 : 17.5 : 8.4 : 5.7 : 3.8 : 2.1 : 2.2, respectively. Ninth sternum (Plate 3, fig. 58) widely subdivided into small hemisternites found at bases of cerci; cercus (Plate 3, fig. 57) somewhat triangular, with a highly setigerous ventral angle; spermathecæ (Plate 3, fig. 59) pear-shaped, brown on apical swollen area, hyaline on basal area, with dark short neck part. Other structures mainly as in male.

Pupa.—Male 3 to 3.2 millimeters long, female 3 to 3.5. Exuviæ dark; head and thorax black; abdominal terga darkly clouded uniformly. Head without frontal tubercles. Thoracic

respiratory organ (Plate 3, fig. 71) hyaline and swollen on basal half, dark, slender and tapering on distal half. Abdominal structures closely resembling those of *S.* (*Eukiefferiella*) *clypeata* Kieffer reported by Dr. A. Thienemann.(12) Chætotaxy: One pair of long setæ (*e*) and four pairs of shorter setæ (*a*, *b*, *c*, and *d*) on dorsal side; two pairs of longer setæ (*i* and *l*) and two pairs of shorter setæ (*j* and *k*) on ventral side; two small setæ (*g*), two minute setæ (*n*) and a spinulous minute papilla at position of setæ *h* on either lateral side; lateral spinulose papillæ present on five segments from second to sixth; setæ *a* and *e* of first tergum and setæ *e* of eighth tergum very long; eighth segment with only two pairs of tergal setæ *e* and *d*, one pair of sternal setæ *l*, two lateral setæ *n*, and two very strong black bristles near *l* setæ on either side. Second to eighth terga each with a caudal transverse ridge of small black spines, these spines arranged in a single line on dark area; terga from third to seventh segment with a number of smaller spines on either lateral side of the spinose ridges. Third to fifth terga each with several black hooklets arranged in a short line just caudad of spinose ridge at either side (Plate 3, fig. 81). Ultimate segment with three long black setæ on caudal end of either lateral tergal lobe; genital sheaths (Plate 4, fig. 94) extending caudad just beyond ends of tergal lobes in male, sheaths very short and hardly visible between bases of tergal lobes in female.

Larva.—Body slender, about 3.2 to 3.5 millimeters long, purplish black. Head conical, elongated, dark brown; eye spots each consisting of a large and a small black pigment mass on a pale, large, oval area. Labrum epipharynx closely similar to that of *Cardiocladius capucinus* Zetterstedt; mandible with four teeth on cutting edge, four minute teeth on molar edge, two simple setæ on base of mesal side; maxilla (Plate 4, fig. 126) with many hyaline trichoid appendages on distal margin; mentum (Plate 5, fig. 133) with a very broad median tooth, five smaller teeth on either side, a pair of simple basal setæ; hypopharynx (Plate 5, fig. 143) with comparatively less trichoid projections on distal margin, median lobe with one pair of comblike and one pair of needlelike projections. Antenna (Plate 4, fig. 99) 5-segmented, mainly brown, distal two segments hyaline. Anterior pseudopod with various serrulate claws (Plate 5, fig. 152), basal, small, strongly serrulate claws arranged into five transverse lines, distal long, slightly serrulate claws arranged into

about three lines; posterior pseudopod with fifteen strong, simple claws; caudal tuft of setæ consisting of seven long, black setæ on a cylindrical chitinized ring; anal gills, dorsal pair short, oval, and ventral pair long, cylindrical.

Nest case.—Larvæ free-living. Pupal nest case closely similar to that of *Cardiocladius fuscus* Kieffer, white, oval, built in a small concavity on stone, about 3.5 millimeters long and 2 wide.

Habitat.—Rapid stream; Honshu, Japan.

Holotype.—Male; Kibune, Kyoto; March 25, 1936.

Allotopotype.—Female; March 25, 1936.

Paratopotypes.—Males and females; March 25, 1936.

Type specimens.—Alcoholic; imagines extruded from mature pupæ, pupæ, and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

This species resembles *S.* (*O.*) *virtunensis* Goetghebuer in the coloration of both sexes and in the structure of the male hypopygium. The latter species differs, however, from the present midge in that the halteres are white, the male antennal ratio is about 1, and the first tarsal segment of the foreleg is about half as long as the tibia.

SPANIOTOMA (ORTHOCLADIUS) SUSPENSA sp. nov.

The immature forms of the present species are common in a mountain stream at Kibune, Kyoto.

Male.—Body about 4 to 4.2 millimeters long, almost entirely black; haltere with stem black, knob white. Head with eyes bare. Antenna 14-segmented; antennal ratio 1.5 to 1.7. Palpus with four distinct segments (5 : 10 : 11 : 16). Thorax with pleural membranes yellow, scutum with brownish areas near wing bases. Legs with tarsal spurs on two proximal segments of middle and hind legs; empodium comparatively short; no pulvilli. Proportional lengths of segments of fore and hind legs 75 : 84 : 58 : 37 : 25 : 17 : 12 and 91 : 95 : 54 : 34 : 25 : 17 : 12, respectively. Wing (Plate 1, fig. 15) with fMCu under fR. Abdominal terga dark brown, with a black median stripe; pale triangular area of first tergum not reaching caudal margin of segment. Hypopygium (Plate 2, fig. 38) similar to that in *S.* (*O.*) *kanii*, with a long, thickly spinulose, anal point.

Female.—Body about 4.5 millimeters long, extensively black. Antenna 6-segmented (3 : 6 : 4 : 3.8 : 4.1 : 9.5), with two short preapical setæ. Scutum somewhat yellowish at shoulder parts and lateral sides; scutellum dark brown. Abdominal terga black,

narrowly yellow along caudal margin of each tergum; sterna yellow, with two dark lateral stripes and a median dark cloud. Relative lengths of segments of fore and hind legs 61 : 69 : 47 : 28 : 22 : 16 : 10 and 72 : 76 : 42 : 26 : 21 : 14.5 : 11, respectively. Cercus (Plate 3, fig. 63) black, with prominent ventral lobe; spermatheca (Plate 3, fig. 64) almost spherical, hyaline, dark brown only at apical part, with curved neck region. Other structures mainly as in male.

Pupa.—Male about 4 millimeters long, female 5; exuviæ hyaline. Head, thorax, and abdominal end dark; abdominal tergum extensively finely spinulose, with a large dark cloud; sternum finely spinulose on anterior part, with a narrow dark band along anterior margin. Head with a pair of minute papillæ on clypeal region, an isolated seta on either general region; labral sheath black on distal margin, with a pair of minute apical points. Thoracic respiratory organ (Plate 3, fig. 70) white, tubular. Chætotaxy of abdominal segments: Five pairs of minute setæ (*a*, *b*, *c*, *d*, and *e*) on tergum, four pairs of minute setæ (*i*, *j*, *k*, and *e*) on sternum, three setæ (*g*, *n*, and *o*) on either lateral side; often ventral setæ *j* or *k* double, sometimes atrophied; ultimate tergum with two caudal lobes which are more widely separated in male than in female, with one pair of anterior setæ on lateral side and one pair of minute setæ on mesal margin of caudal incision. Abdominal terga with characteristic spinose black patches (Plate 3, fig. 80); second to fifth terga each with a small oval patch on caudomesal ridge, spines on this patch directed cephalad; third to eighth terga each with a larger oval patch on cephalomesal part, spines on this patch directed caudad; third to seventh terga each with a pair of very finely spinulose ridges on caudal margin, these ridges somewhat obscure in third segment. Genital sheaths in male extending caudad far beyond caudal lobes of ultimate tergum, in female ending before caudal ends of tergal lobes (Plate 3, fig. 85).

Larva.—Body about 6 to 7 millimeters long, almost entirely dark green in life. Head yellowish brown or brown, with a pair of oval dark clouds on lateral sides before eye spots, a small dark cloud on clypeal region; eye spot rather variable, usually consisting of two small spherical masses of pigment and sometimes of a single reniform mass of pigment. Antenna (Plate 4, fig. 100) short, 5-segmented; first segment with a large hyaline and a short dark sensory projection; second segment with an apical visorlike projection. Labrum (Plate 4, fig. 118) with a pair of unequally bifurcate distomesal appendages which are not pro-

vided with a common basal plate; epipharynx (Plate 4, fig. 118) with three large mesal teeth between U-sclerite, besides eight pairs of lateral teeth; premandible (Plate 4, fig. 118) strongly angulated; mandible with four small cutting teeth and a long apical tooth; brustia minutely serrulate. Maxilla (Plate 4, fig. 122) without marginal spines on outer lobe, with many dark strong spines on mesal lobe. Mentum (Plate 5, fig. 135) with a very broad mesal tooth and about eight small teeth on either lateral side, basal setæ bifid. Hypopharynx (Plate 5, fig. 145) thickly fringed with strong brown spines on lateral sides; median lobe provided with five or six pairs of yellow spatulate projections; dorsal wall with many small, dark-brown, scalelike projections. Anterior pseudopod with numerous yellow claws, these claws arranged in about six or seven transverse lines; those arranged on basal four or five lines distinctly pectinate and those of distal two lines very long, almost simple (Plate 5, fig. 151). Posterior pseudopod with sixteen long black claws. Caudal tuft of setæ consisting of six long black setæ on small fleshy tubercle, latter with a minute chitinized plate on caudal side. Anal gills equally oval and short.

Nest case.—Larval nest case cylindrical, about 20 to 37 millimeters long, 2.6 to 3.5 millimeters in diameter, fixed on stone at one end, thickly covered with sedentary diatoms and appearing entirely green. Pupal nest case similar in size to larval nest case, with an oval pupal chamber at free end; pupal chamber somewhat pointed at distal end, with one respiratory opening at either end of chamber, about 7 millimeters long and 3.2 wide.

Habitat.—Mountain stream; Honshu, Japan.

Holotype.—Male; Kibune, Kyoto; March 25, 1936.

Allotopotype.—Female; March 25, 1936.

Paratopotypes.—Males and females; March 25, 1936.

Type specimens.—Alcoholic imagines, pupæ, and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

The immature forms are somewhat allied to *S.* (*O.*) *rivulorum* Kieffer, reported by Dr. A. Potthast,(7) but in the allied species the pupa carries imbricate tubular respiratory organs, posterior tergal spinose patches that are elongate and concave cephalad, and spinose complete ridges, each of which consists of a single line of spines, along caudal margins of fourth to sixth terga. The imagines are somewhat related to *S.* (*O.*) *rubicunda* Meigen and *S.* (*O.*) *nivium* Kieffer; they are, however, different in the structures of the male ultimate tergum. In the latter species, more-

over, the lateral sides of the thorax and abdomen are somewhat white and the relative length of the foretibia and first tarsal segment is about 15: 10, in this respect differing from the present fly.

SPANIOTOMA (ORTHOCLADIUS) SAXOSA sp. nov.

This species is common on stones in a rapid stream in winter.

Male.—Body about 3.5 millimeters long, almost entirely black; pseudosutural areas somewhat dark brown. Head with eyes bare; antenna 14-segmented; antennal ratio about 1.3. Middle and hind legs with tarsal spurs on two proximal segments; empodium comparatively short; relative lengths of segments of foreleg about 15: 17.6: 14: 9.4: 7.3: 5.3: 3.8, of hind leg 21.7: 22.6: 13.8: 8.9: 6.4: 4.6: 3.7. Hypopygium with setigerous anal point; coxite with a small mesal lobe; style (Plate 2, fig. 39) with a prominent triangular preapical ridge.

Female.—Body about 3.4 to 3.8 millimeters long, yellow in ground color, with three distinctly separated black scutal vittæ. Head black, with antenna 6-segmented (21.5: 36.8: 19.8: 21.3: 21.8: 58.5); ultimate antennal segment with an apical seta, pubescent on distal two-thirds with hyaline hairs. Palpus with four distinct segments (23: 51: 46: 72). Thorax extensively yellow; scutum with three black vittæ, median vitta sometimes separated; scutellum brown; postscutellum black; pronotum with a brown cloud at either lateral side; pleural side very extensively yellow, sclerites brown, a black spot on either side near wing base; sternepisternum with a black stripe which is narrowly separated from the black sternal area by a yellow stripe. Halteres yellow. Legs with coxæ black, trochanters and bases of femora yellow; other parts black; tarsal spurs present on three proximal segments of middle and hind legs; leg ratio of foreleg about 0.77 (0.75 to 0.8). Wing (Plate 1, fig. 16) dark by transmitted light, yellow on basal area; fMCu under fR; Cu_1 sinuous at tip. Abdomen dark brown on dorsal side, brown on ventral side, narrowly yellowish brown on caudal margin of each tergum; ultimate segment darker; cerci (Plate 3, fig. 62) with long ventral lobe, yellowish brown; spermathecæ oval, mainly brown, somewhat yellow on basal third or more, black on neck region.

Pupa.—Body about 3.5 to 3.8 millimeters long in male and 4 in female, mainly dark brown, without swimming hairs and lateral expansions. Head with two distinct frontal tubercles. Thoracic respiratory organs (Plate 3, fig. 61) white, oval; paratergal margin with a prominent tubercular lobe before wing

base. First to third or fourth abdominal segments each with a papilliform swelling on caudal part of either lateral side; second to ninth terga each with a finely spinulose area on cephalic half; eighth tergum with a pair of minute tubercles on caudal margin; second to sixth abdominal sterna each with a finely spinulose area on caudal half; seventh and eighth sterna each with a pair of finely spinulose small areas along cephalic margin; sixth and eighth sterna each with a pair of thickly spinose dark areas on caudolateral part. Chætotaxy of abdomen: Tergum with five pairs of small setæ *a*, *b*, *c*, *d*, and *e*, sternum with four pairs of minute setæ *i*, *j*, *k*, and *l*, lateral side with two small dorsal *g* and *h* and a ventral *n* seta on middle part; eighth segment with only tergal *e* setæ, sternal *l* setæ, and somewhat with double *n* setæ; ultimate segment without setæ. Characteristic arrangement of spinose ridges and patches as follows: Second and third terga each with a distinct spinose ridge along caudal margin, about one-third as long as caudal margin and carrying numerous black spines grown cephalad; fourth and fifth terga (Plate 3, fig. 77) each with a smaller black, spinulose patch just along cephalic margin of the spinose ridge, which is similar in structure to that of the preceding segment, this spinulose patch carrying numerous minute black spinules which are all grown caudad; sixth and seventh terga each with a larger caudal spinulose patch which is similar in structure to that of the two preceding segments but larger, being about one-third or more of caudal margin of segment. Ultimate segment (Plate 3, fig. 89) with a pair of small black tergal lobes; genital sheaths of male very long, straight, extending caudad beyond caudal lobes of ultimate tergum; those of female very short but visible in dorsal aspect, being slightly beyond caudal lobes.

Larva.—Body about 4.5 millimeters long, greenish brown in ground color in life. Head brown, lateral and ventral side extensively yellow. Antenna (Plate 4, fig. 97) mainly brown; ultimate segment hyaline. Labrum (Plate 4, fig. 117) with paired distomesal appendages equally bifurcate; epipharynx (Plate 4, fig. 117) with five large hooks between arms of U-shaped chitinization, a large oval proximal plate; premandible (Plate 4, fig. 109) distinctly spatulate, and with a pointed tip. Mandible with four small cutting teeth, two plumose hairs at base. Maxilla (Plate 4, fig. 125) fringed thickly with scalelike and strong trichoid spines; palpus flattened disclike. Mentum (Plate 5, fig. 134) with three large median teeth, a pair of large lateral and four pairs of small pointed lateral teeth. Hypo-

pharynx (Plate 5, fig. 146) not thickly fringed, with only two strong lateral spines and several sensillæ on either side; median lobe branched into four pairs of trichoid projections of which one pair are finely serrulate. Anterior pseudopod with various claws (Plate 5, fig. 153) which are golden yellow and arranged into about fifteen transverse lines; claws of basal four lines very slender, small, simple; those of next six lines variously serrate; those of next three lines long, slender, serrate only on apical one-third or more; those of two distal lines very long, slender, simple. Posterior pseudopod with sixteen large, black, simple claws. Caudal tuft of setæ consisting of five short setæ grown on small fleshy tubercle. Dorsal pair of anal gills short, oval; ventral pair slender, tubular.

Nest case.—Larval nest cases clearly hyaline, gelatinous, somewhat irregular, closely applied to stones along small crevices on surface, about 10 to 16 millimeters long and 3 to 5 wide in full-grown larvæ. Pupal nest cases also clearly hyaline and gelatinous, somewhat oval, closely adhering on stones with short stems; chamber part about 7 to 10 millimeters long and 4 to 6 wide; stem part about 3 millimeters long.

Habitat.—Rapid stream; Honshu, Japan.

Holotype.—Male; Kibune, Kyoto; March 25, 1936.

Allotopotype.—Female; March 25, 1936.

Paratopotypes.—Males and females; March 25, 1936.

Type specimens.—Alcoholic imagines, pupæ, and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

The present species is allied to the following species: *S.* (*O.*) *rubicunda* Meigen, *S.* (*O.*) *thienemanni* Kieffer, and *S.* (*O.*) *oblidens* Walker. These allied species, however, may be easily distinguished from the present species in the following points: In *S. rubicunda* the male hypopygium is provided with a bare ultimate tergum, and the ridges of the styles are slightly developed; in *S. thienemanni* the two distal tarsal segments of all legs are subequal in length, the male antennal ratio is about 2, and the male hypopygium is provided with a very large mesal lobe of the coxite; in *S. oblidens* the male antennal ratio is about 2 and the style of the hypopygium carries a very slightly developed ridge. The immature forms of the present species closely resemble those of *S. thienemanni;* the pupa of the latter, however, is not provided with the spinose ridge on the second tergum. Similar pupal nest cases are also known in the cases of

S. thienemanni Kieffer, *S. rivicola* Kieffer, and *S. minuta* Zetterstedt.

SPANIOTOMA (ORTHOCLADIUS) FILAMENTOSA sp. nov.

This species is commonly found in a rapid stream in Kyoto. The immature forms build their nest cases on stones of clear streams.

Male.—Body about 4 millimeters long, almost entirely black; scutellum somewhat dark brown; haltere with white knob. Head with eyes bare; antenna 14-segmented, with antennal ratio about 1.9. Legs without pulvilli; middle and hind legs with tarsal spurs on two proximal segments; leg ratio about 0.73 to 0.75 in foreleg and 0.58 to 0.62 in hind leg. Wing (Plate 1, fig. 17) with costa slightly produced beyond end of R_{4+5}, R_{2+3} ending before middle between ends of R_1 and R_{1+5}, R_1 about half as long as R_{4+5}, fMCu under crossvein. Coxite of hypopygium very long, with a prominent basal lobe on mesal side; style (Plate 2, fig. 40) flattened, with a preapical ridge slightly developed; ultimate tergum without setæ; anal point long, pubescent, with strong scattered spinules.

Female.—Body about 4.2 millimeters long. Head entirely dark brown; antenna 6-segmented (25 : 38 : 24 : 23 : 21 : 68); its ultimate segment entirely pubescent with small hyaline hairs, with a long and a small apical seta, subequal in length to three preceding segments taken together. Thorax extensively yellow at side; pronotum brown, somewhat dark at side; scutum brown, with a dark-brown median vitta and two black lateral vittæ on brown ground color, these three vittæ subconfluent; scutellum brown; postscutellum black; pleural sclerites entirely black. Haltere with white knob. Wing with basal part yellow, R_1 longer than half of R_{4+5}, end of R_{2+3} slightly separated from end of R_1. Abdominal terga entirely brown. Cercus (Plate 3, fig. 65) pale brown; ultimate sternum subdivided into hemisternites which are very widely separated, highly setigerous, projecting caudoventrad; spermathecæ somewhat oval, mainly dark brown, with basal part brown. Other structures largely as in male.

Pupa.—Body about 4.5 to 5 millimeters long; exuviæ extensively dark; abdominal dorsal side extensively dark; caudal area of each tergum hyaline. Head with vertex, labrum, compound eyes, and antennal bases dark brown, other parts pale brown, without frontal tubercles, with three pairs of small setæ: One pair on vertex between antennal bases and two setæ on either

genal part. Thorax with several black setæ and three small papilliform tubercles on either side. Thoracic respiratory organs (Plate 3, fig. 72) white, filiform, rarely slightly branched only at tip. Abdomen with lateral expansions on four caudal segments, without lateral swimming hairs; segments from second to seventh finely spinulose in varying extent on both dorsal and ventral sides; first, eighth, and ninth segments without spinulose areas. Chætotaxy as follows: Tergum typically with five pairs of setæ (*a*, *b*, *c*, *d*, and *e*), sternum also with five pairs of setæ (*i*, *j*, *k*, *l*, and *m*), either lateral side with two *n* setæ and one *o* seta; *a*, *e*, *i*, and *j* setæ longer than others; *d* setæ often absent on first three segments; first segment with *g* seta on lateral side and only one pair of *i* setæ on ventral side; eighth segment with only one pair of *e* setæ on dorsal side, one pair of *m* setæ on ventral side, and single *g*, *n*, and *o* setæ and double *h* setæ on either lateral side; these setæ of eighth segment stronger than in other segments; ultimate segment with only three very strong black setæ at caudal end of each tergal lobe. Characteristic arrangement of spinose ridges (Plate 3, figs. 79 and 82) as follows: Second tergum with a large caudal ridge which is about half as long as caudal margin of segment and composed of small black hooklets arranged into about three lines; these hooklets curved dorsocephalad; each hooklet with a minute tooth at shoulder part; third to fifth terga each with a long caudal ridge which is almost as long as entire caudal margin of segment and composed of small black spines arranged into about three lines; these spines extending straight dorsocephalad; sixth tergum without special spinose ridge, its mesal spinose area with strong spines on caudal part along margin; fourth to sixth sterna each with a pair of small spinulose areas on caudolateral parts. Ultimate segment (Plate 4, fig. 93) of male with genital sheaths extending straight caudad, beyond tergal lobes; female genital sheaths almost as long as tergal lobes.

Larva.—Body about 6 to 7 millimeters long in full-grown stage, yellowish green. Head brown, with pale round areas around eye spots. Antenna (Plate 4, fig. 101) 5-segmented. Labrum with a pair of unequally bifurcate distomesal appendages, one very strong simple appendage and many simple trichoid appendages along distal margin of either lateral side; epipharynx with a large median hooklike tooth, nine lateral hooklike teeth of various sizes, and two lateral simple spines between U-shaped thickening, a small basal thickened plate (Plate 4, figs.

108 and 119). Mandible comparatively slender, with four cutting teeth. Maxilla (Plate 5, fig. 127) with a tuft of strong spines on mesal lobe, many scalelike marginal spines on both lobes. Mentum (Plate 5, fig. 136) with a very broad median tooth, truncate apically, first lateral teeth broad, other five pairs of lateral teeth pointed, basal setæ simple, single. Hypopharynx (Plate 5, fig. 147) thickly fringed with long spines, with a pair of very strong preapical spines, median lobe with a pair of minute dorsal papillæ, a pair of trichoid projections and many flattened projections; dorsal wall distinctly imbricate, with many small comblike scales. Anterior pseudopod with numerous claws of various sizes which are arranged into about fifteen transverse lines; claws of two basal lines minute, simple; those of next eight lines variously serrate; those of following four lines elongate, finely serrulate basally and roughly serrate apically; those of distal line very slender, finely serrulate only on basal part (Plate 5, fig. 158). Posterior pseudopod with sixteen slender, simple claws. Caudal tuft to setæ composed of six long setæ grown on small fleshy papilla. Four anal gills similar in shape and size, elongate, tubular, somewhat swollen on basal half.

Nest case.—Both pupal and larval nest cases built on stones with muddy debris, somewhat tubular, closely applied with entire length on stones along crevices; cases of full-grown larvæ and pupæ about 10 to 12 millimeters long and about 3 to 4 millimeters wide.

Habitat.—Torrential stream; Honshu, Japan.

Holotype.—Male; Kibune, Kyoto; March 25, 1936.

Allotopotype.—Female; March 25, 1936.

Paratopotypes.—Males and females; March 25, 1936.

Type specimens.—Alcoholic imagines, pupæ, and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

This torrential midge somewhat resembles *S.* (*O.*) *thienemanni* Kieffer and *S.* (*O.*) *nivium* Kieffer, but may be distinguished from them by the following characters of the male: In the first allied species, antennal ratio about 2, two scutal stripes between vittæ dull yellow, and scutal vittæ less shiny. In the second allied species antennal ratio about 1.5, pleural side with white clouds, foreleg ratio about 0.67, costal vein of wing not produced beyond end of R_{4+5}, and lateral sides of abdomen white.

SPANIOTOMA (TRICHOCLADIUS) INTERMEDIA sp. nov.

The present species was often collected in mountain streams in winter. The prepupal and pupal forms are found in hyaline gelatinous nest cases closely applied to stones, while the younger larvæ are free-living, actively crawling on the surface of stones.

Male.—Body about 3 millimeters long, entirely black. Head with eyes pubescent. Antenna 14-segmented; antennal ratio about 1.1. Thorax with very minute humeral pits. Legs with tarsal spurs on two proximal segments of middle and hind legs; no pulvilli; proportional lengths of segments of legs 16.8 : 21.7 : 15.5 : 9.4 : 7.5 : 5.6 : 3.8 in foreleg and 21.7 : 25.5 : 13.1 : 8.4 : 6.8 : 4.6 : 3.8 in hind leg. Wing with costal vein very slightly produced beyond end of R_{4+5}, R_{2+3} ending at one-fourth between ends of R_1 and R_{4+5}, fMCu slightly beyond fR. Hypopygium with ultimate tergum slightly setigerous at caudolateral margins; anal point roughly spinose with short strong spines; coxite slender, slightly swelling mesad, with a basal triangular lobe; style (Plate 2, fig. 41) with a large dorsal thickened ridge.

Female.—Body about 3.5 millimeters long, color as in *S.* (*O.*) *saxosa* or more yellowish. Antenna 6-segmented (18 : 32 : 22 : 20 : 24 : 42), with two preapical setæ, scape yellow. Proportional lengths of segments of fore and hind legs: 18.4 : 23.5 : 16.5 : 10.9 : 8.2 : 6 : 3.8 and 24.6 : 29.7 : 15.1 : 9.2 : 7.5 : 4.7 : 3.8, respectively. Cercus (Plate 3, fig. 60) with large ventral lobe; spermathecæ as in *S.* (*O.*) *saxosa*. Other structures mainly as in male.

Pupa.—Body, male, about 3.5 millimeters long; female, 4. Exuviæ with head, thorax, and ultimate tergum yellowish brown; abdominal dorsal side yellow, ventral side hyaline. Head with paired frontal tubercles pointed in male and blunt in female, without distinct setæ. Thorax without respiratory organs. Abdomen without lateral swimming hairs and expansions; third to eighth terga in male and third to ninth in female spinulose on cephalomesal area, sterna from second to seventh very finely spinulose on anterior area. Abdominal chætotaxy as follows: Tergum typically with five pairs of small setæ (*a*, *b*, *c*, *d*, and *e*), sternum with four pairs of minute setæ (*i*, *j*, *k*, and *l*), either lateral side with a dorsal *g* and two ventral *n* and *o* setæ; eighth segment with only two pairs of dorsal *e* and *g* setæ; ultimate segment without setæ. Characteristic arrangement of spinose patches as follows: Third to eighth terga each with a black spinose patch along caudal margin; these spinose patches consisting of black spines, about two-fifths as long as caudal

margin of segment; spines of patches arranged in about five transverse lines and extending straight caudad (Plate 3, fig 74). Genital sheaths of male very long, distinctly upcurved, of female very short but visible in dorsal aspect between tergal lobes (Plate 3, fig. 84).

Larva.—Body about 5.5 to 6.2 millimeters long in full-grown stage, largely purplish black; thoracic segments somewhat paler. Head black, with black double eye spots on yellow oval areas. Antenna (Plate 4, fig. 102) 5-segmented, with a large trichoid sensilla which is slightly shorter than four distal segments put together, minute ultimate segment hyaline, other segments black. Labrum with a pair of equally bifurcate distomesal appendages on a common cordiform plate, other appendages all simple and trichoid. Epipharynx closely similar to that of *S.* (*O.*) *filamentosa,* but each lateral group of hooklike teeth composed of only four teeth and basal plate elongate, differing from teeth in *S. filamentosa.* Mandible with five cutting teeth, a plumose basal seta on mesal edge. Maxilla (Plate 5, fig. 129) with disclike palpus, fringed with many hyaline trichoid spines. Mentum (Plate 5, fig. 137) with median tooth broad, slightly subdivided apically; first lateral teeth broad, blunt apically; other five lateral pairs smaller, pointed; basal setæ simple. Hypopharynx (Plate 5, fig. 148) fringed with simple spines on lateral side, with two strong simple spines and one plumose spine on either distolateral margin, median lobe branched into four pairs of serrulate projections. Anterior pseudopod with various yellow claws which are arranged into about twenty transverse lines; claws of four basal lines simple, those of thirteen middle lines short, pectinate, and those of three distal lines slender, pectinate only on apical part (Plate 5, fig. 155). Posterior pseudopod with sixteen claws which are large, black, strongly curved, and simple. Setæ of caudal tuft six, very long, grown on a small fleshy common tubercle. Anal gills with dorsal pair elongate and oval; ventral pair longer, constricted at middle, basal part swollen distinctly.

Nest case.—Cases built in prepupal stage, hyaline, gelatinous, oval, about 8 to 10 millimeters long and 5 wide.

Habitat.—Clear mountain stream: Honshu, Japan.

Holotype.—Male; Kibune, Kyoto; March 25, 1936.

Allotopotype.—Female; March 25, 1936.

Paratopotypes.—Males and females extruded from mature pupæ; March 25, 1936.

Type specimens.—Alcoholic imagines, pupæ, and larvæ; deposited in the entomological laboratory, Kyoto Imperial University; collected by M. Tokunaga.

The pupa of the present species is distinctly different from other known *Trichocladius* pupæ in the absence of anal bristles of the ultimate tergal lobes. The imago is intermediate in type between two groups, *Trichocladius* and *Acricotopus;* both sexes, highly differing from known members of *Trichocladius,* are not provided with pulvilli; the male, differing from known species of *Acricotopus,* is provided with a distinct anal point, and the female carries 6-segmented antennæ.

CHIRONOMINÆ

CHIRONOMUS (CHIRONOMUS) CRASSIFORCEPS Kieffer.

Tendipes crassiforceps KIEFFER, Ann. Mus. Nat. Hung. 14 (1916) 111, 112.

The present specimens of this species were collected from a hot spring, about 38°C. in temperature, at Sozan, Taihoku.

Male.—Body about 3.5 to 5.2 millimeters long; thoracic ground color white; abdomen brown. Head and mouth parts uniformly brown, with paired frontal tubercles. Antenna 12-segmented; antennal ratio about 1.6. Thorax with four distinct scutal vittæ on white scutum, median vittæ brown, lateral vittæ dark brown; scutellum pale brown; postscutellum black; pleural sclerites mainly brown, dorsal part of sternepisternum white. Legs entirely brown, with large brown pulvilli; foretibia with a blunt apical projection; proportional lengths of segments of foreleg 78 : 65 : 95 : 45 : 38 : 35 : 18, of middle leg 78 : 74 : 32 : 19 : 16 : 11 : 10, and of hind leg 90 : 82 : 45 : 25 : 24 : 14 : 11. Wing about 2.7 millimeters long, with veins yellowish brown, crossvein brown; fMCu beyond fR, 1A extending beyond fMCu. Haltere white. Abdomen and hypopygium brown; eighth tergum somewhat pale brown on caudal half. Hypopygium (Plate 2, fig. 42) with ultimate tergum setigerous; anal point thickened, not trilobate; style very large, oval in lateral aspect, with numerous short, strong spines on mesal side of apical half; dorsal appendage long, slender, bare; ventral appendage slender, almost as long as style, without special apical recurved setæ.

Female.—Body about 3.4 to 4.5 millimeters long. Antenna 6-segmented (20 : 39 : 32 : 33 : 28 : 61), scape yellow, flagellum pale brown; intermediate flagellar segments each with a distinct neck region; ultimate segment with only one preapical seta.

Palpus 5-segmented (13 : 15 : 31 : 45 : 73). Legs with proportional lengths of segments 56 : 44 : 70 : 34 : 28 : 26 : 14 in foreleg, 56 : 57 : 26 : 14 : 12 : 9 : 7 in middle leg, and 65 : 64 : 40 : 22 : 20 : 10.5 : 9 in hind leg. Wing (Plate 1, fig. 18) broad, slightly constricted on caudal margin at end of Cu_1. Other structures mainly as in male.

Pupa.—Body about 5 to 6 millimeters long. Head with a pair of distinct frontal tubercles, each of which carries a small apical seta. Thoracic respiratory organ as in *C.* (*C.*) *dorsalis* Meigen but smaller. Second abdominal tergum with a caudal ridge of hooklets, these hooklets each with one or two minute teeth at shoulder part; fifth to eighth segments each with a lateral lamella and four long swimming hairs on either lateral side; eighth segment with a pair of thin simple spines on caudolateral angles; ultimate segment with a pair of lateral semicircular lamellæ which are very thickly fringed with short setæ arranged into two or three lines.

Larva.—Body about 7 millimeters long, blood-red in life. Head yellowish white, black only on eye spots, mentum, apical parts of mandibles, and occipital margin; eye spot consisting of three very widely separated masses of pigment, of which the dorsal one is large, reniform, the ventral one large and distinctly constricted, the caudal one very small. Antenna (Plate 4, fig. 98) 5-segmented; first segment about twice as long as four following segments taken together. Labrum epipharynx with appendages closely similar to those of *C.* (*C.*) *dorsalis*, but median plumose appendage of labrum (Plate 4, fig. 111) broad and more strongly pectinate, distomesal comblike appendage of ephipharynx with about twenty teeth. Mandible (Plate 4, fig. 112) with four cutting teeth, molar edge serrulate into three small teeth, with four basal short plumose projections. Maxilla (Plate 5, fig. 128) closely resembling that of *C.* (*C.*) *dorsalis*. Mentum (Plate 5, fig. 138) with three median teeth, of which the lateral pair are small; six pairs of lateral teeth pointed. Hypopharynx (Plate 5, fig. 149) fringed with hyaline, comblike scales on distal margin and with long spines on lateral margins. Anterior pseudopod with numerous simple hairlike claws on ventral side, claws of several distal transverse lines (Plate 5, fig. 159) long, finely serrulate. Posterior pseudopod with sixteen golden-brown simple claws. Eighth abdominal segment with two lateral filaments on either side, of which the caudal filament is longer, but not longer than the segment. Caudal tuft of setæ consisting of

seven long setæ which grow on a small fleshy tubercle. Anal gills equally elongate and tubular.

Habitat.—Hot spring of sulphurous water; Formosa.

Specimens.—Alcoholic males, females, pupæ, and larvæ; Sozan, Taihoku; deposited in the entomological laboratory, Kyoto Imperial University; collected by Dr. R. Takahashi.

The imagines are somewhat different from the descriptions given by Dr. J. J. Kieffer,(3) the type specimens being said to have the antennal ratio about 2 and the ventral appendage of the male hypopygium to carry long setæ on its apical one-third.

CHIRONOMUS (CHIRONOMUS) ACERBIPHILUS sp. nov.

This species was collected from a pond of highly acidic water, pH about 1.4, at Katanuma.

Male.—Body about 5.5 to 6 millimeters long, ground color black. Antenna 12-segmented; antennal ratio about 2.68. Thorax pruinose. Legs with dark-brown pulvilli; foreleg ratio about 1.2. Haltere dark brown. Wing with black crossvein. Abdomen almost entirely black; terga somewhat paler along caudal margin. Hypopygium (Plate 2, fig. 43) with anal point slender; style with dorsal thickened ridge; dorsal appendage with apical part irregularly serrulate; ventral appendage comparatively short, extending caudad not far beyond anal point.

Female.—Body about 6 millimeters long. Antenna 6-segmented (5 : 8 : 6 : 6 : 7.5 : 18); antennal ratio about 0.67; second segment slightly constricted; intermediate flagellar segments each with a short neck region. Foreleg ratio about 1.24. Spermathecæ two, equal, hyaline, short-oval; cercus (Plate 3, fig. 66) black, somewhat angulated. Other structures mainly as in male.

Habitat.—Acidic water; Honshu, Japan.

Holotype.—Male; Katanuma, Miyagi Prefecture; May, 1937.

Allotopotype.—Female; May, 1937.

Paratopotypes.—Males and females; May, 1937.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University; collected by Mr. K. Fujimatsu.

This species is very closely allied to *C.* (*C.*) *lugubris* Zetterstedt, but the two are distinguished from each other by difference in the structures of the male hypopygium and by the shape of the female cerci, mentioned above.

TANYTARSUS (MICROPSECTRA) TAIWANUS sp. nov.

This midge was collected at Gokan, Formosa, altitude, about 3,000 meters.

Male.—Body about 4.5 millimeters long, black in ground color. Head almost entirely dark brown, with very small frontal tubercles; antenna dark brown, 14-segmented; antennal ratio about 1.4. Pronotum dark brown; scutum black, slightly shiny; scutellum dark brown; postscutellum black; pleural and sternal sclerites dark brown. Legs dark brown; basal ends of all femora pale brown; pulvilli present, about half as long as claws. Wing (Plate 1, fig. 20) about 3.5 millimeters long, uniformly dark, with macrotrichia on distal one-third. Haltere pale brown. Abdominal terga mainly dark brown, black on caudal margin. Hypopygium (Plate 2, fig. 45) with anal point short, bare; dorsal appendage swollen, setigerous, with a small accessory lobe; ventroproximal appendage pubescent on stem, with flattened setæ on apical part.

Habitat.—Mountain region; Formosa.

Holotype.—Alcoholic male; Gokan, Taichyu Prefecture; August 13, 1936; deposited in the entomological laboratory, Kyoto Imperial University; collected by Dr. R. Takahashi.

This species is somewhat related to *T.* (*M.*) *brunnipes* Zetterstedt and *T.* (*M.*) *fuscus* Meigen; but the former is not provided with pulvilli and the latter is specific, with the antennal ratio about 2.

TANYTARSUS (STEMPELLINA) OKADAI sp. nov.

This small midge was collected from hot spring water, about 36°C. in temperature.

Male.—Body about 1.6 to 1.8 millimeters long, brown in ground color. Head brown, with V-shaped black thickening on vertex; eyes bare; frontoclypeus with about ten setæ; frontal tubercles represented only by blunt swellings of integument. Antenna with scape dark brown, flagellum and plumose hairs brown, 13-segmented, but two distal segments obscurely segmented; ultimate segment shorter than four preceding segments taken together (56 : 63.5) antennal ratio about 0.35 to 0.4. Palpus brown, 5-segmented (8 : 12.5 : 34 : 29 : 40). Thorax with scutum reddish brown, lateral vittæ black, median vittæ reddish brown, these four vittæ separated by a middorsal line of about ten pale setigerous dots and two lateral lines of about five pale dots, shoulder parts yellowish brown; scutellum reddish brown and somewhat paler than scutum, with two long median and two short lateral setæ; postscutellum dark brown; pleural and sternal sclerites brown; pleural membranes yellowish brown. Legs with coxæ brown, other segments pale brown; foretibia with a

fixed apical spine; other tibiæ each with two small separated combs each of which carries one short spur; no pulvilli; no beards; foreleg ratio about 1.5. Wing (Plate 1, fig. 19) cuneiform, pale brown by transmitted light, R_{4+5} ending before level of end of M_{4+5}, fMCu beyond fR; macrotrichia present in cells R_5 and M_2. Haltere yellowish brown. Tergal side of abdomen brown, with pale dots at bases of setæ; sternal side yellowish brown. Hypopygium (Plate 2, fig. 44) with anal point short, setigerous and pubescent; style slender; dorsal appendage fusiform, setigerous, with a slender accessory lobe; ventroproximal appendage slender, with simple setæ.

Habitat.—Hot spring water; Honshu, Japan.

Holotype.—Male; Tsubame-Onsen, Niigata Prefecture; July 19, 1937.

Paratopotypes.—Males; July 19, 1937.

Type specimens.—Alcoholic; deposited in the entomological laboratory, Kyoto Imperial University; collected by Prof. Dr. Y. Okada and Mr. S. Ito.

This species is somewhat allied to *T.* (*S.*) *cuneipennis* Edwards; in the allied species, however, the foreleg ratio is about 1.6, vein R_1 is shorter than half of R_{4+5}, the marginal fringe of wing is very long, and the wing margin is more angulated at end of Cu_1.

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ILLUSTRATIONS

[Drawings by Miss Hisayo Taniguti and M. Tokunaga.]

Plate 1

Fig. 1. *Pentaneura esakii* sp. nov.; male, wing.
2. *Pentaneura esakii* sp. nov.; female, wing.
3. *Heptagyia brevitarsis* (Tokunaga); female, wing.
4. *Brillia modesta* Meigen; male, wing.
5. *Brillia japonica* sp. nov.; female, wing.
6. *Metriocnemus* (*Parametriocnemus*) *stylatus* Kieffer; male, wing.
7. *Cardiocladius capucinus* Zetterstedt; male, wing.
8. *Cardiocladius fuscus* Kieffer; female, wing.
9. *Spaniotoma* (*Smittia*) *nudipennis* Goetghebuer; male, wing.
10. *Spaniotoma* (*Smittia*) *niitakana* sp. nov.; male, wing.
11. *Spaniotoma* (*Smittia*) *truncatocaudata* sp. nov.; male, wing.
12. *Spaniotoma* (*Eukiefferiella*) *takahashii* sp. nov.; male, wing.
13. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; male, wing.
14. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; female, wing.
15. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; male, wing.
16. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; female, wing.
17. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; male, wing.
18. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; female, wing.
19. *Tanytarsus* (*Stempellina*) *okadai* sp. nov.; male, wing.
20. *Tanytarsus* (*Micropsectra*) *taiwanus* sp. nov.; male, wing.
21. *Cardiocladius esakii* sp. nov.; female, fourth tarsal segment of hind leg.
22. *Cardiocladius capucinus* Zetterstedt; male, fourth tarsal segment of hind leg.
23. *Cardiocladius fuscus* Kieffer; female, fourth tarsal segment of hind leg.
24. *Metriocnemus stylatus* Kieffer; male, distal part of antenna.

Plate 2

Fig. 25. *Anatopynia nebulosa* Meigen; male, coxite and style.
26. *Pentaneura esakiana* sp. nov., male, basal projection of coxite.
27. *Pentaneura esakii* sp. nov.; male, coxite and style.
28. *Brillia modesta* Meigen; male, hypopygium.
29. *Brillia japonica* sp. nov.; male, hypopygium.
30. *Metriocnemus* (*Parametriocnemus*) *stylatus* Kieffer; male, hypopygium.
31. *Cardiocladius capucinus* Zetterstedt; male, hypopygium.
32. *Spaniotoma* (*Smittia*) *nudipennis* Goetghebuer; male, hypopygium.
33. *Spaniotoma* (*Smittia*) *niitakana* sp. nov.; male, hypopygium.
34. *Spaniotoma* (*Smittia*) *truncatocaudata* sp. nov.; male, hypopygium.

FIG. 35. *Spaniotoma* (*Eukiefferiella*) *takahashii* sp. nov.; male, hypopygium.
36. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; male, coxite with style and anal point.
37. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; male, coxite and style.
38. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; male, coxite and style.
39. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; male, style.
40. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; male, style.
41. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; male, style.
42. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; male, hypopygium.
43. *Chironomus* (*Chironomus*) *acerbiphilus* sp. nov.; male, hypopygium.
44. *Tanytarsus* (*Stempellina*) *okadai* sp. nov.; male, hypopygium.
45. *Tanytarsus* (*Micropsectra*) *taiwanus* sp. nov.; male, hypopygium.
46. *Heptagyia brevitarsis* (Tokunaga); female, cercus.
47. *Heptagyia brevitarsis* (Tokunaga); female, spermatheca.
48. *Brillia japonica* sp. nov.; female, cercus.
49. *Brillia japonica* sp. nov.; female, spermatheca.
50. *Cardiocladius capucinus* Zetterstedt; female, lateral projection of ninth abdominal segment.
51. *Cardiocladius capucinus* Zetterstedt; female, cercus.
52. *Cardiocladius capucinus* Zetterstedt; female, spermatheca.
53. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; female, cercus.
54. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; female, spermatheca.
55. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; female, spermatheca.

PLATE 3

FIG. 56. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; female, cercus.
57. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; female, cercus.
58. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; female, lateral projection of ninth abdominal segment.
59. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; female, spermatheca.
60. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; female, cercus.
61. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; pupa, respiratory organ.
62. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; female, cercus.
63. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; female, cercus.
64. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; female, spermatheca.
65. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; female, cercus.
66. *Chironomus* (*Chironomus*) *acerbiphilus* sp. nov.; female, cercus.
67. *Anatopynia nebulosa* Meigen; pupa, respiratory organ.
68. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; pupa, respiratory organ.
69. *Heptagyia brevitarsis* (Tokunaga); pupa, respiratory organ.
70. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; pupa, respiratory organ.

FIG. 71. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; pupa, respiratory organ.
72. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; pupa, respiratory organ.
73. *Anatopynia nebulosa* Meigen; pupa, third and seventh abdominal terga.
74. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; pupa, sixth abdominal tergum.
75. *Cardiocladius capucinus* Zetterstedt; pupa, seventh abdominal tergum and sternum.
76. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; pupa, seventh abdominal tergum and sternum.
77. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; pupa, fifth abdominal tergum.
78. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; pupa, fifth abdominal tergum.
79. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; pupa, second abdominal tergum.
80. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; pupa, fourth abdominal tergum.
81. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; pupa, third abdominal tergum.
82. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; pupa, fifth abdominal tergum.
83. *Cardiocladius capucinus* Zetterstedt; male pupa, abdominal end.
84. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; female pupa, abdominal end.
85. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; male pupa, last abdominal tergum.
86. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; female pupa, abdominal end.
87. *Anatopynia nebulosa* Meigen; male pupa, abdominal end.
88. *Heptagyia brevitarsis* (Tokunaga); female pupa, abdominal end.
89. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; female pupa, abdominal end.
90. *Cardiocladius capucinus* Zetterstedt; female pupa, abdominal end.
91. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; male pupa, abdominal end.

PLATE 4

FIG. 92. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; male pupa, abdominal end.
93. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; male pupa, abdominal end.
94. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; male pupa, abdominal end.
95. *Heptagyia brevitarsis* (Tokunaga); larva, antenna.
96. *Cardiocladius capucinus* Zetterstedt; larva, antenna.
97. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, antenna.
98. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, antenna.

FIG. 99. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; larva, antenna.
100. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; larva, antenna.
101. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, antenna.
102. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; larva, antenna.
103. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, antenna.
104. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; larva, antenna.
105. *Cardiocladius capucinus* Zetterstedt; larva, premandible.
106. *Heptagyia brevitarsis* (Tokunaga); larva, premandible.
107. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, premandible.
108. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, premandible.
109. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, premandible.
110. *Heptagyia brevitarsis* (Tokunaga); larva, dorsal side, anterior and posterior parts.
111. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, distomesal appendage of labrum.
112. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, mandible.
113. *Cardiocladius capucinus* Zetterstedt; larva, labrum epipharynx.
114. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; larva, labrum epipharynx.
115. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, epipharynx.
116. *Heptagyia brevitarsis* (Tokunaga); larva, labrum epipharynx.
117. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, labrum epipharynx.
118. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; larva, labrum epipharynx.
119. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, labrum epipharynx.
120. *Heptagyia brevitarsis* (Tokunaga); larva, maxilla.
121. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; larva, maxilla.
122. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; larva, maxilla.
123. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, maxilla.
124. *Cardiocladius capucinus* Zetterstedt; larva, maxilla.
125. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, maxilla.
126. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; larva, maxilla.

PLATE 5

FIG. 127. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, maxilla.
128. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, maxilla.
129. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; larva.
130. *Cardiocladius capucinus* Zetterstedt; larva, mentum.
131. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; larva, mentum.
132. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, mentum.
133. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; larva, mentum.
134. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, mentum.
135. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; larva, mentum.
136. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, mentum.
137. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; larva, mentum.
138. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, mentum.
139. *Heptagyia brevitarsis* (Tokunaga); larva, mentum.

FIG. 140. *Heptagyia brevitarsis* (Tokunaga); larva, hypopharynx.
141. *Cardiocladius capucinus* Zetterstedt; larva, hypopharynx.
142. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; larva, hypopharynx.
143. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; larva, hypopharynx.
144. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, hypopharynx.
145. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; larva, hypopharynx.
146. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, hypopharynx.
147. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, hypopharynx.
148. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; larva, hypopharynx.
149. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, hypopharynx.
150. *Heptagyia brevitarsis* (Tokunaga); larva, claws of posterior pseudopod.
151. *Spaniotoma* (*Orthocladius*) *suspensa* sp. nov.; larva, claws of anterior pseudopod.
152. *Spaniotoma* (*Orthocladius*) *tentoriola* sp. nov.; larva, claws of anterior pseudopod.
153. *Spaniotoma* (*Orthocladius*) *saxosa* sp. nov.; larva, claws of anterior pseudopod.
154. *Cardiocladius capucinus* Zetterstedt; larva, claws of anterior pseudopod.
155. *Spaniotoma* (*Trichocladius*) *intermedia* sp. nov.; larva, claws of anterior pseudopod.
156. *Spaniotoma* (*Orthocladius*) *kibunensis* sp. nov.; larva, claws of anterior pseudopod.
157. *Spaniotoma* (*Orthocladius*) *kanii* sp. nov.; larva, claws of anterior pseudopod.
158. *Spaniotoma* (*Orthocladius*) *filamentosa* sp. nov.; larva, claws of anterior pseudopod.
159. *Chironomus* (*Chironomus*) *crassiforceps* Kieffer; larva, claws of anterior pseudopod.

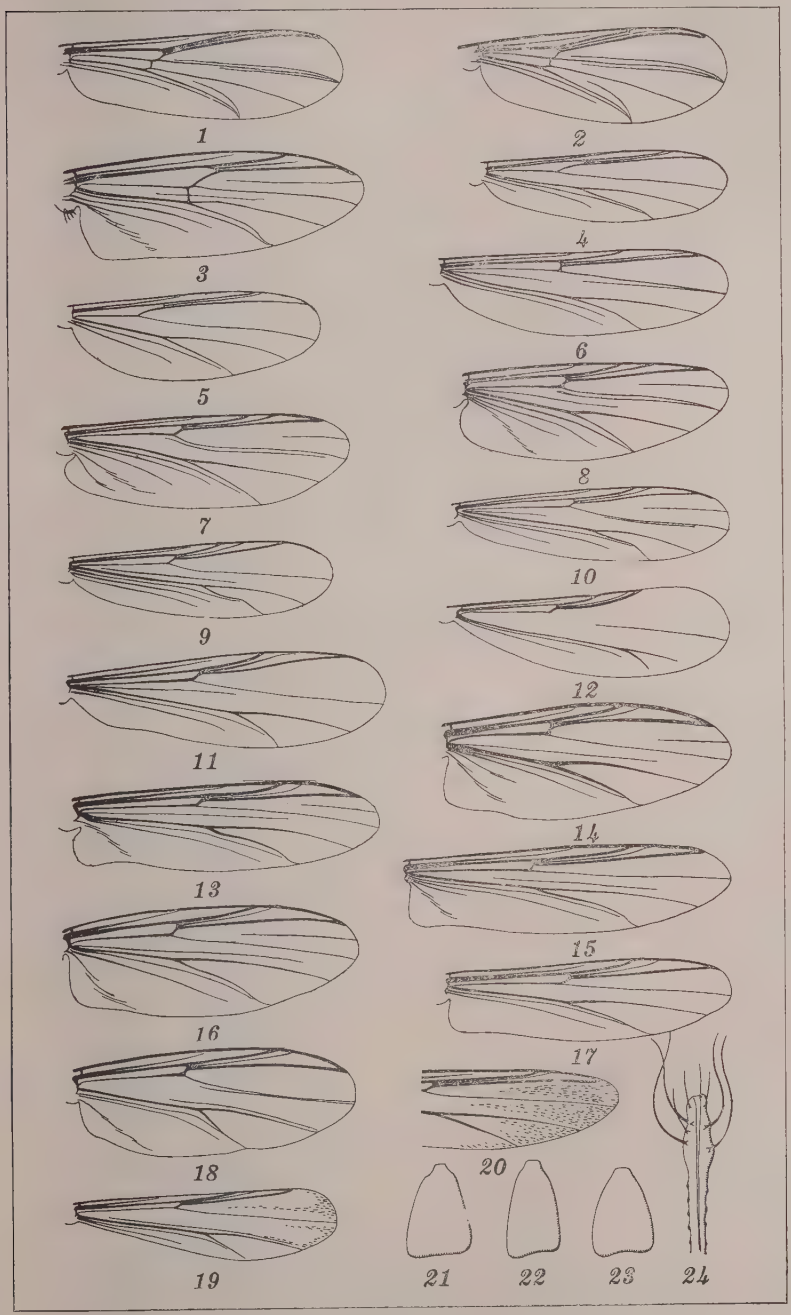

PLATE 1.

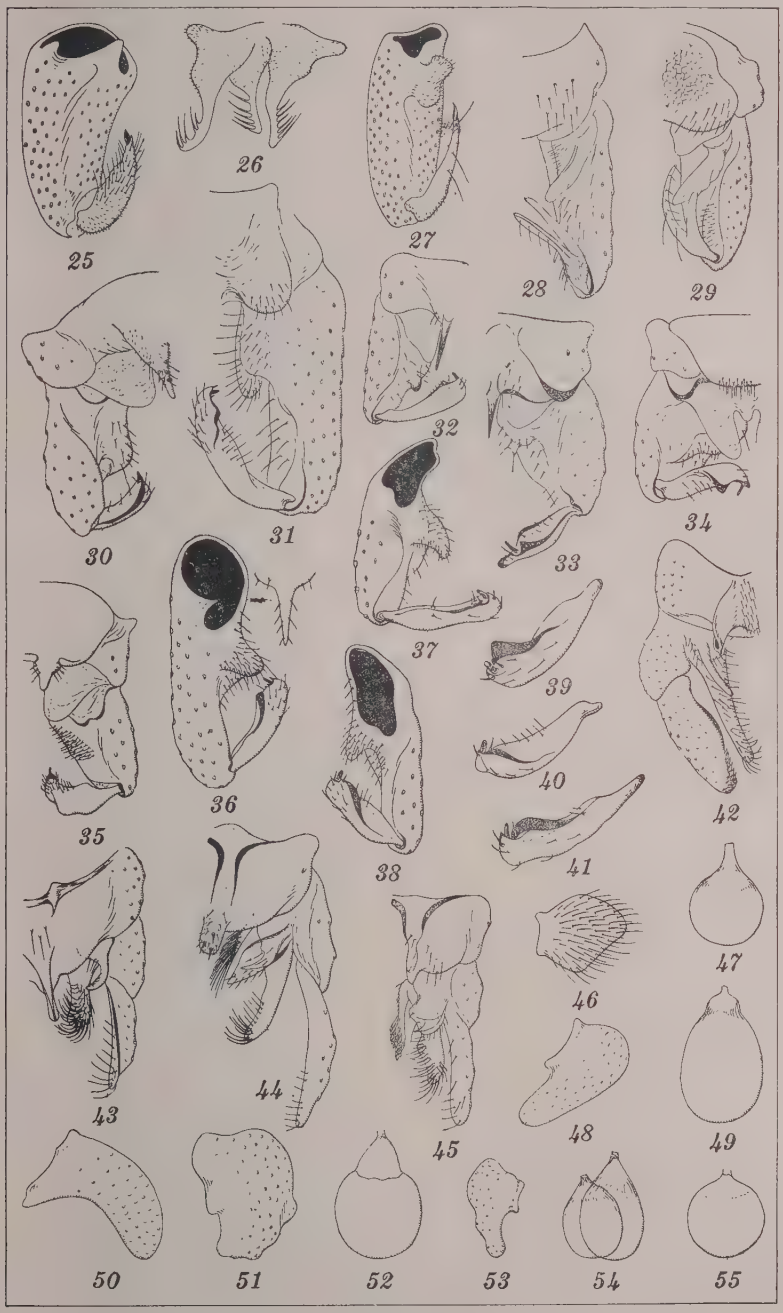
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PLATE 2.

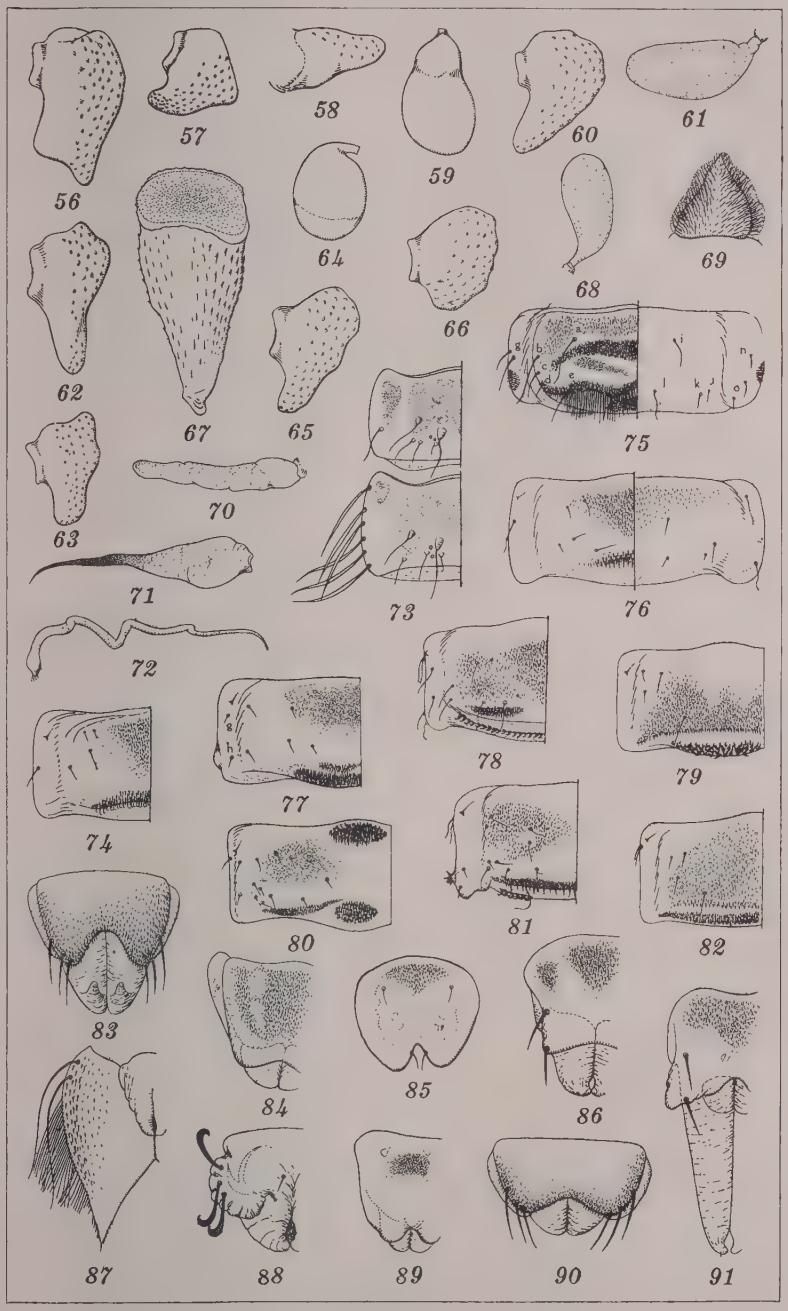
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PLATE 3.

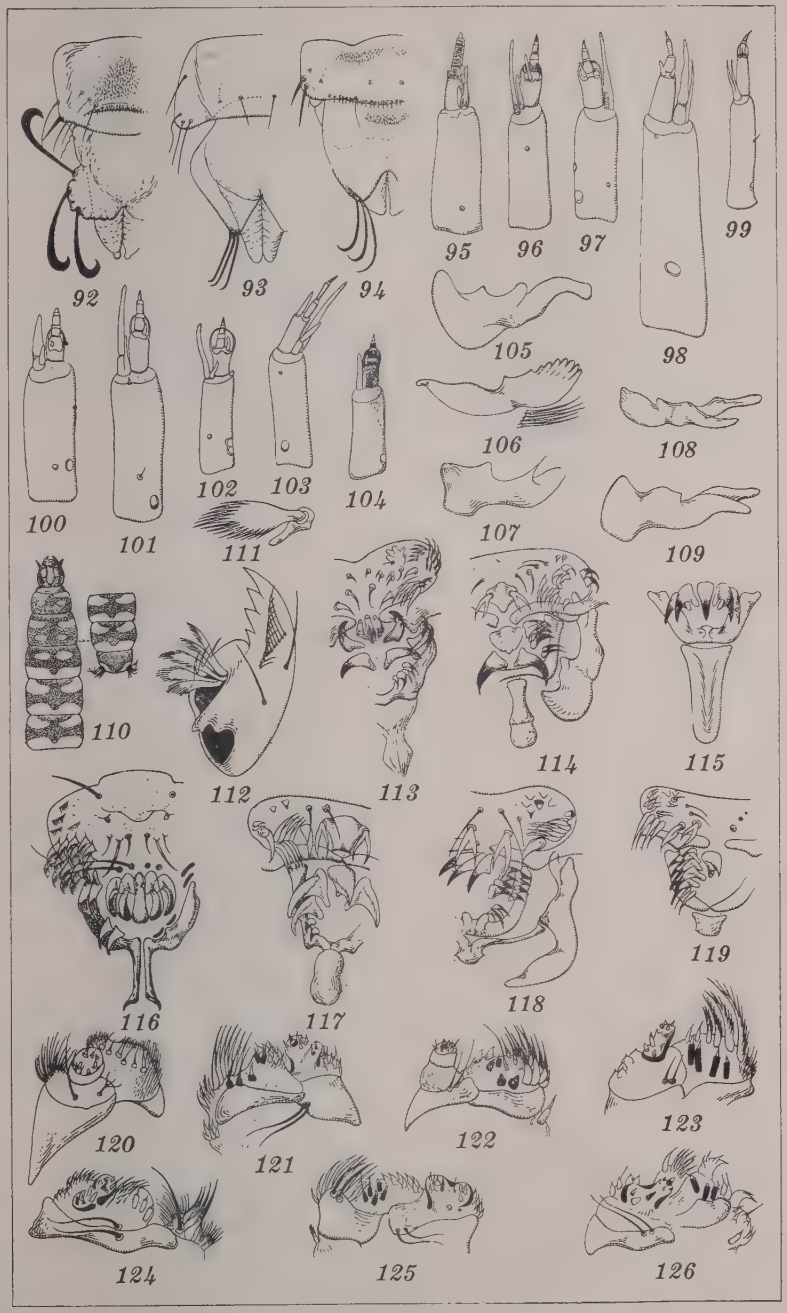
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PLATE 4.

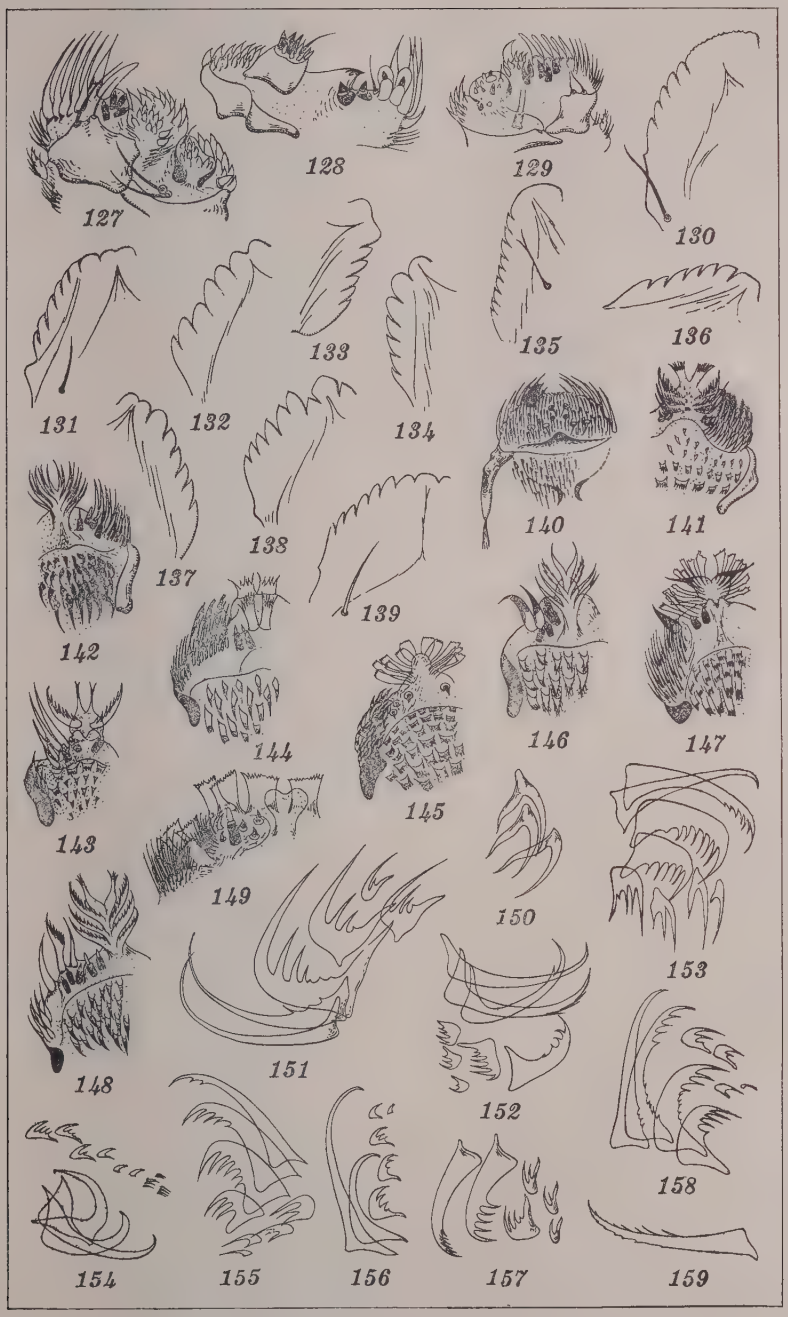
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PLATE 5.

STUDIES ON THE ANATOMY OF REMIPES TESTUDINARIUS LATREILLE, WITH SOME OBSERVATIONS ON ITS RELATIVE MORPHOLOGICAL AFFINITY

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FOUR PLATES

Only 4 species and 1 variety of the tribe Hippidea, distributed among 3 genera and 2 families, are known in the Philippines. They are as follows: Family Albuneidæ: *Albunea symnista* (Linnæus) and *Albunea microps* White; family Hippidæ: *Mastigochirus quadrilobatus* Miers, *Remipes testudinarius* Latreille, and *Remipes testudinarius* var. *denticulatifrons* (White). *Albunea symnista* and *Remipes testudinarius* and its variety are represented in the collection of the University of the Philippines. *A. microps* and *M. quadrilobatus* are mentioned only in foreign literature.(13)

The greater portion of this work on *R. testudinarius* was done at the Marine Biological Laboratory of the University of the Philippines at Puerto Galera, Mindoro, during a period embracing five summer sessions of about six weeks each.

The attempt to include the development of this animal did not have encouraging results, and this phase of the work had to be laid aside due to lack of opportunity, equipment, and appropriate methods of meeting the natural requirements of the developing embryos.

Embryos of different stages up to the zœa were obtained by catching the ovigerous females. Laboratory observations on stages later than the first zœa could not be made, because under captivity the females bearing embryos in this stage invariably shed them, and once separated from the mother the embryos live but a few hours. All efforts to make the zœa live longer and to bring about their development by artificially simulating their natural environment by constructing an artificial beach proved futile.

Claus(2) rejects the suborder Anomura and refers the Hippidea to the Brachyura, on the basis of what is known of their development. A more detailed knowledge of the develop-

ment of this animal will therefore throw some light on its relative position. It is the purpose of this work to study some of the peculiar morphological adaptive characteristics coincident to the animal's particular habitat, and to show, in a measure, to what extent internal organization, particularly that of the nervous system, supports the existing divergent views regarding the relative morphological affinity of the tribe Hippidea to which this species belongs.

ACKNOWLEDGMENT

I wish to take this opportunity to express my gratitude to Dr. Hilario A. Roxas, who, in spite of his manifold duties as head of the Fish and Game Administration, Bureau of Science, and as professorial lecturer in the University of the Philippines, found time to go over this paper. To the members of the staff of the Zoölogy Department of the College of Liberal Arts I wish to express my indebtedness for their constant encouragement and for coöperation rendered in various ways.

Order DECAPODA

Suborder ANOMURA

Tribe HIPPIDEA

Family HIPPIDÆ Stimpson, 1858

Genus REMIPES Stimpson

Remipes STIMPSON (1858, p. 229); LATREILLE (1806, p. 45); MILNE-EDWARDS, H. (1837, p. 204).

REMIPES TESTUDINARIUS Latreille.

Hippa adactyla FABRICIUS (1793, p. 474); LATREILLE (1803, p. 176).
Cancer emeritus HERBST (1796, p. 8, pl. 22, fig. 4).
Remipes testudinarius LATREILLE (1806, p. 45); LAMARCK (1818, p. 223); MILNE-EDWARDS, H. (1837, p. 406, pl. 21, figs. 14–20); HELLER (1865, p. 72); MIERS (1879, p. 316).
Remipes marmoratus WHITE (1847, p. 58); MIERS (1876, p. 59).
Remipes pacificus DANA (1852, p. 407, pl. 25, fig. 7); STIMPSON (1862, p. 241).
Remipes hirtipes DANA (1852, p. 408, pl. 25, fig. 8).
Remipes pictus HELLER (1861, p. 243).
Remipes ovalis MILNE-EDWARDS, H. (1863, p. 12, pl. 17, fig. 5).

Stebbing is of the opinion that the true name should be *R. adactylus*, the species having been named *Hippa adactyla* by Fabricius in 1793. The nomenclature as revised by Miers(13) is followed in this paper.

According to Miers this species is the one most widely distributed of the family. Specimens were collected from the Australian Seas, the Red Sea, from Mauritius, Zanzibar, Reunion, Nicobars, Soloo Island, Moluccas, Flores, the Philippines, Onsima, New Hebrides, Mallicollo, Fiji Islands, Ovalau, Samoa or Navigator's Islands, Sandwich Islands, Tahiti, from California, and from St. Lucas.

In the Philippines specimens were collected from Guimaras Island, Iloilo Province; Puerto Galera, Mindoro Province; Bauan, Batangas Province; La Union Province; Ilocos Sur Province; Ilocos Norte Province; and Aparri, Cagayan Province.

These crabs are popularly known as "mole shrimps," or "sand bugs," from their habit of burrowing under the sand. In Iloko they are called "ipis." They live gregariously along the water line in loose sandy beaches, preferring a mixture of fine gravel and coarse sand. In this respect they differ from the closely allied species, *Albunea symnista,* which prefers the finer and more compact sand. They follow the water line as it recedes during low water and as it advances at high tide. In sheltered places of bays and coves, where the makeup of the beach remains practically the same, these animals abound from year to year, as I observed for a period of about ten years in some places in Puerto Galera, Mindoro, in spite of the fact that sometimes the people collect them for food. On open seacoasts, like those of the Ilocos provinces, they shift with the shifting sand.

To catch them, the collector, with his back to the water, simply scoops up a handful of sand and shoves it farther up shore. He has to be quick and sharp-eyed, however, for the crabs run back quickly to the water, with their posterior end first, and dig into the sand and disappear within a few seconds. Sometimes they simply lie quietly as if dead, and as their color wonderfully harmonizes with that of the sand, they may easily escape the notice of the collector.

The color of these crabs varies with that of the sand where they live, the general background, however, usually being whitish to grayish, with arenaceous spots. They may be aptly described as "sand-colored."

EXTERNAL ANATOMY

Eyes.—The peduncles are slender, usually extending a little beyond the end of the basal joint of the antennules. There are three joints, the last one bearing the cornea. At the outer prox-

imal angle of the second joint is found a clump of fine plumed setæ.

Antennules.—The antennules are placed just below the eyes. The peduncle has three joints and bears two flagella. The primary or dorsal flagellum bears clumps each with from four to seven short and pointed chitinous tactile bristles (Plate 1, fig. 1, *tr b*), those on the ventral side being longer and not in cluster. The secondary or ventral flagellum bears around its joints long tactile bristles, those at the tip forming a clump (Plate 1, fig. 1, *f*). The bristles on the peduncles are of two kinds; those on the sides and upper surface are simple, while those on the under surface are plumed.

Antennæ.—The peduncle is 3-jointed. The primary flagellum has three segments and bears long simple tactile bristles. The secondary flagellum is rudimentary and invested with plumed bristles (Plate 1, fig. 2, f_2). In normal position the peduncle is inclined medially, and the flagella meet at the angle of the suboperculiform terminal joint of the third maxilliped which is held appressed over the buccal cavity.

The simple bristles on the antennules and antennæ apparently are sensory, while the plumed ones in conjunction with those found in the first and second maxillæ are perhaps accessory devices, acting as a sieve to prevent sediment from getting into the branchial chamber.

Mandibles.—The mandibles coordinate with and closely invest the walls of the oral opening. Their position is at the angle of the calcified triangular anterior portion and the noncalcified posterior portion of the wall of the mouth. The mandible appears rudimentary, apparently serving merely as an attachment of the palpus, which is attached at about the proximal third of the protognathite (Plate 1, fig. 3, *a*). The free margin of the outer portion of the palpus projects at an obtuse angle in front, facing the branchial channel. This margin is armed with about six or seven very short and stout obtuse spines at its anterolateral angle (Plate 1, fig. 3, *d*). The inner branch of the palpus (Plate 1, fig. 3, *c*), lying just above the labrum and closely appressed to it, is somewhat orbicular. Its terminal margin is armed with numerous long branching spinulose setæ, which evidently help in preventing sediment from getting into the buccal cavity.

First maxillæ.—The terminal portion of the inner lobe is a thick, heavily calcified rectilinear plate joined to the basal with a broad articulation (Plate 1, fig. 4, *a*). The terminal margin

of the first maxilla is armed on its outer edge with a series of six very large, short, stout, conical dentiform spines; at the angle at each end of the series are smaller spines. On the short posterior margin are several slender spinules. On the inner margin are numerous spinulous setæ which curve inward. The protognathal lobe bears plumose setæ. The exopodite is long, very narrow to near the expanded, spatulate extremity, the convex margin of which is densely armed with setæ which are stout and spiniform, except anteriorly where they are long and plumed. Similar plumed setæ invest the sides and the margin of its broad basal portion, on the lower margin of which are a few spinules.

Second maxillæ.—The second maxilla is composed of a protopodite, a median endopodite, and an outer exopodite known as scaphognathite. The protopodite is composed of a coxopodite and a basipodite. The coxopodite is composed of two lobes, one broadly rounded, the other, smaller and conical, situated between the former and the endopodite. The endopodite projects over the buccal opening, just anterior to the teeth-bearing terminal portion of the endopodite of the first maxilla which likewise hangs over the opening of the mouth. Its terminal margin is invested with stiff long setæ, which, together with those fringing the lateral margin of the endopodite of the first maxilliped and those of the first maxillæ, form a very efficient sieve to prevent the entrance of sediment into the buccal cavity. The exopodite (scaphognathite) is a thin membranous plate (Plate 1, fig. 5, *ex*) modified as a gill bailer that bails the water out of the prebranchial chamber. Its margin is heavily invested with featherlike hairs, the barbs of which form a very fine network which, while it helps to create the water currents, serves at the same time as an efficient strainer for fine sediments.

First maxilliped.—The exopodite of the first maxilliped (Plate 2, fig. 6) is composed of two joints, the terminal one falciform in outline with a concavity at the anterolateral angle. This fits into the bases of both the antennæ and antennule, and is rimmed with long and bushy stiff plumose setæ, which, together with those found at the bases of the antenna and the antennule, form an efficient means for preventing the entrance of sediment into the branchial chamber. The posterolateral margin fits into that of the inner anterolateral angle of the branchiostegite, while the long inner margin is held appressed to the side of the raised triangular anterior portion of the wall of the mouth. The endopodite (Plate 2, fig. 6, *d*) is a semielliptic calcified plate with

the side next to the buccal opening concave. It extends over the whole length of the buccal opening, and, together with that of the other pair, forms a sort of trap door closing the buccal aperture. The rim is thickly invested with plumed setæ, those of the inner posterior margin longer and more bushy. Along the inner margin are stout teeth fitting into the similarly arranged row of teeth of the other pair.

Second maxilliped.—The exopodite of the second maxilliped (Plate 2, fig. 7, *d*) is reduced into a 2-jointed filiform structure and densely invested with longish plumed setæ at its lateral margins. The endopodite is 4-jointed, the last joint broadly triangular and bearing a crown of stout spinulose bristles. Similar bristles invest the inner surface and outer margin of the preceding joint. These two joints are held appressed over the buccal opening. Dense plumose setæ line the lateral margins of the first two joints, and similar setæ crown the protognathal lobe (Plate 2, fig. 7, *b*).

Third maxilliped.—The third maxilliped is suboperculiform; its second joint is greatly enlarged, and the last is unguiform. In natural position the third maxillipeds are held over the buccal region, with the surface appressed to the mouth bearing strong bristles: elsewhere there are long plumose setæ (Plate 2, fig. 8). The exopodite is a 2-jointed delicate filamentous structure, rather rudimentary and bearing plumose setæ at the margins.

Legs.—The anterior legs are elongated, clothed with rather long hairs, which are densest on the inner margins and show a tendency to disposition in oblique series on the upper and outer margins of the last two joints. The last joint tapers somewhat to its extremity, which is clothed with long hairs. This leg is held parallel to the body and extends far beyond the anterior end of the body.

The second, third, and fourth pairs of legs are robust. The terminals of the second and third pairs are slightly falcate; the distal half short, broad, and obtusely rounded at the extremity. The distal half of the fourth pair is narrow and straight. The shape and structure of the second and third pairs of legs make them efficient tools for the animal in digging its way into the sand.

The last pair is more or less rudimentary in both sexes. In natural position it lies folded close to the fourth. Its last joint (Plate 3, fig. 11) is forked, the inner margin of the fork being

spoon-shaped. The hairs that invest the joints become more bushy around the forks. In the female this leg is evidently used in transferring the eggs and glueing them to the abdominal appendages which are provided with long setæ for the attachment of the eggs, and presumably in detaching the embryo at the time of hatching, as females bearing immature zœæ when placed in a pan of water were observed to shed the young by the rapid movements of the legs and the uropods.

Carapace.—The carapace is moderately convex and marked with numerous fine interrupted transverse lines. The postfrontal sinuses are distinct, the frontal lobes moderately prominent, obtuse, and rounded, and the lateral ones scarcely project beyond the median lobes. Series of shallow pits bordered with tufts of short hairs form a linear submarginal striated area on the lateral margins.

Abdomen.—The first segment of the abdomen is concave anteriorly, and fits closely to the carapace; two lines clothed with hairs traverse it, the anterior starting on either side of the somewhat prominent median dorsal elevation. The second segment is small, only about one-third the breadth of the first segment. The third and fourth, still smaller than the second, are hexagonal. The fifth and sixth are fused.

The telson is long, lanceolate, about seven-tenths the length of the carapace. The uropods are attached at the anterolateral angle. The two branches are flattened laterally and clothed with long hairs, the exopodite a bit longer than the endopodite (Plate 2, fig. 10, *u*). The tips of both are clothed with plumed setæ. In life the telson and abdomen are closely held under the body, the flexion being between the first and second abdominal segments, the telson reaching as far as the base of the first legs and over the buccal region.

Summary of the body somites and the corresponding appendages.—There are five pairs of appendages on the head and eight pairs on the thorax. There are four pairs of abdominal appendages in the female, excluding the uropods, and only one in the male. The appendages are as follows:

CEPHALON

Somite.	Appendages.
1	first antennæ (antennules)
2	second antennæ
3	mandibles
4	first maxillæ
5	second maxillæ

THORAX

Somite.	Appendages.
6	first maxillipeds
7	second maxillipeds
8	third maxillipeds
9	first pair of pereiopods
10	second pair of pereiopods
11	third pair of pereiopods
12	fourth pair of pereiopods
13	fifth pair of pereiopods

ABDOMEN

Somite.	Appendages (female).
14	first pleopods
15	second pleopods
16	third pleopods
17	fourth pleopods
18	fifth and sixth somites fused — no pleopods
19	last bears telson and uropods

INTERNAL ANATOMY

Digestive system.—The buccal cavity is imperfectly defined. The only prominent portion of the mouth is the raised triangular calcified portion that forms the anterior wall, the posterior wall being not well defined. The two horns produced by the extension of the posterior lateral angles of the calcified anterior wall clasp the soft labrum, whose sides extend posteriorly to form the lateral wall of the buccal opening. The posterior margin of the labium is entire and convex, while the anterior portion is divided into three lobes; the two lateral lobes meet the extension of the labrum. The pharynx is a short tube inclining almost vertically to the dorsal side to a short œsophagus which leads to the stomach, a roughly polygonal sac with a very thin membranous wall except in its posterior portion.

The stomach is divided into two distinct portions, the pyloric and the cardiac. Viewed from the dorsal surface, the cardiac portion appears like a broadly bilobed bag with the lobes extending laterally. The pyloric portion is short and narrow, hanging more or less vertically. The wall of the region near the pyloric region is thick and holds the three teeth of the gastric mill. The teeth are disposed in a manner similar to those found in the gastric mill of Macrura and Brachyura; one tooth is placed ventrally and the two other dorsolaterally. The pyloric opening leading to the intestine is practically in the same line with the opening to the œsophagus, at a short distance posteriorly. The small intestine extends from the pyloric portion of the stomach

to the anal opening which is situated at about the proximal third of the telson.

The digestive gland is known as the hepatic cæca, a very complicated lobed mass closely investing the stomach and extending the whole length of the intestine.

Feeding habits.—Prof. S. I. Smith (1874–1878) concluded: "the mouth parts of the adults are not adapted for ordinary prehension or mastication, but I am unable to make any positive statement in regard to the food of these animals. In all specimens examined the alimentary canal was filled with fine sand which seemed to be free from animal or vegetable matter. The material from the stomach, however, shows under the microscope a small quantity of vegetable matter, and it seems probable that the sand is swallowed for the nutritive matter it may contain."

The suggestion of Professor Smith that the animal swallows the sand for the organic matter it may contain cannot be supported by the character of the structure of the mouth organs and the alimentary canal. It is a physiological impossibility; for the crab, in order to get the necessary amount of food, would have to swallow a great deal of the coarse sand in which it lives buried. The alimentary canal, therefore, would have to be constructed for the passage of large amounts of debris, like in that of the earthworm or in holothurians, where the alimentary canal is more or less a straight tube and of about the same width throughout. In *R. testudinarius* the stomach is a big sac and the intestine a delicate and small tube. Moreover, if the animal simply extracts the organic matter from the sand it swallows, it has no need for the gastric mill, which is an organ for grinding and trituration; this organ then is not only useless, but is a hindrance to the passage of the large amount of debris that the animal has to swallow.

In the stomach contents of a number of individuals examined I found a large quantity of broken pieces of appendages of smaller crustaceans, presumably amphipods, isopods, some spicules of sponges, and some very small snails, as well as very fine sand grains. The animal may either be predaceous or a scavenger, possibly both. In this connection it should be recalled that the third maxillipeds are suboperculiform; the last segment is unguiform and provided with stout bristles on the inner surface of the last two joints; similar bristles crown the last joint of the second maxilliped and the inner surface of the preceding joint; a row of teeth lines the inner edge of the endopodite of

the first maxilliped—all these, in conjunction with the series of teeth and spinules of the first maxillæ, will be efficient organs for seizing and holding the prey. Besides those structures, there are the elaborate plumose setæ which have been mentioned before. These structures will hinder the process of swallowing, if the animal simply swallows sand for the organic matter it can extract. On the other hand, the obvious purpose of these plumose structures is to prevent the entrance of sand into the buccal cavity.

The few grains of sand found in the stomach were evidently taken with the food. As the sand is being continually stirred up by the waves, a few grains of sand are likely to enter into the mouth, especially during the process of ingestion, in spite of the presence of the elaborate plumose setæ in the mouth parts.

RESPIRATION

The prebranchial chamber is formed in the following manner: The anterior portion of the mouth is raised into a kind of a triangular wall with its apex more elevated and pointing anteriorly. In each side of this triangular wall is a broad concavity which increases the space between the buccal wall and the bases of the antennules and the antennæ. Over this space, as a sort of a roof, is the broad, flattened falciform terminal segment of the exopodite of the first maxilliped. The inner edge of this segment is appressed into the edge of the triangular buccal wall, while its posterolateral margin fits into that of the anterolateral margin of the branchial wall, and the concave anterolateral margin with its investment of bushy plumose setæ fits into the bases of the antennules and the antennæ, which have been described before as similarly clothed. These plumed structures strain the water currents that pass through the space between the antennules and through the space between these and the antennæ. The complicated movements of the exopodite of the second maxilla drives the water into the branchial chamber over the gills.

The branchial wall is articulated to the side of the carapace by a thin chitinous arthrodial membrane to allow the wall a certain amount of movement. The branchial wall is calcified as far as the base of the second pair of legs; from here posteriorly it is a muscular flap, an extension of the dorsal body wall with the margin free. The movement of this muscular flap in part, that of the branchial wall in general, and, to a certain extent, that of the gills, force the water out of the branchial chamber

through the canals between the rows of lamellæ that compose each gill through the spaces between the legs and alongside of the pleura of the carapace and the abdomen.

A continuous current of water is made to pass over the gills, entering at the opening between the bases of the antennules and through the space between the bases of the antennules and the antennæ, bailed out by the scaphognathite from the prebranchial chamber into the branchial chamber, and from here driven out as described.

There are nine pairs of gills, all of the phyllobranchiate type. They are elongated and tapering toward both ends, and are placed oblique to the longitudinal axis of the body. Each gill is composed of a double row of broadly ovate laminated plates attached to a horizontal attachment which in turn is attached at about its middle point by a short membranous fold of the arthrodial membrane of the coxopodite of the gill-bearing appendages. This arrangement allows the gills a certain amount of freedom of movement anteroposteriorly. The first five gills are bent just above their middle point, each making an obtuse angle that faces posteriorly. This adaptation serves two purposes: To allow more space at the opening of the branchial chamber, and at the same time to make the current of water move posteriorly.

The branchiæ are placed as follows: The first pair of gills are attached by a membranous extension (arthrodial membrane) at the base of the coxopodite of the third maxilliped. The others are similarly attached by the arthrodial membrane fold—the second and third pairs to the base of the coxopodite of the first pereiopod; the fourth and fifth pairs, the sixth and seventh, and the eighth and ninth pairs to the bases of the second, third, and fourth pereiopods, respectively. All gills are podobranchs, since they are all attached to the bases of the appendages. Plate 3, fig. 13, shows one of the gills.

REPRODUCTIVE SYSTEM

The male gonad (Plate 3, fig. 11) is composed of a testis consisting of five lobes and a short and threadlike vas deferens which enlarges posteriorly to form a bigger tube, the seminal vesicle. The seminal vesicle narrows posteriorly to form a short ejaculatory duct which opens to the genital papilla at the base of the last thoracic leg. This leg, as previously described, has chelate fingers which are spoon-shaped and clothed with a thick brush. The spoon-shaped fingers probably serve to transfer the

sperm. The gonad can be easily removed by removing the legs, cutting through the sternum, and pulling the last thoracic leg.

The female gonad is located at the side of the stomach running along side of the intestine. The oviduct opens at the space between the first and the second abdominal appendages. In nonovigerous females it is quite difficult to discern the ovary, but in ovigerous females it practically fills the cephalothoracic cavity. The eggs are at first irregular, becoming more rounded as soon as they are extruded, and measure about a millimeter in diameter.

The nature of the development of this animal presents an interesting field for investigation. The writer in his attempts was able to observe only as far as the first zœa stage, partly due to the fact that the ovigerous female under laboratory conditions invariably sheds the embryo, which then cannot be induced to proceed with its development, even under artificially simulated conditions of the beach. Plate 4, figs. 16 to 19, shows some of the stages in development.

CIRCULATORY SYSTEM

The circulation of the blood can be partly seen quite plainly in the zœa through the transparent carapace. The heart is pentagonal, and lies within the pericardium on the dorsal side of the cephalothorax, giving off three arteries from the anterior end, the artery in the median line running to the base of the rostrum. This is the ophthalmic artery in the adult, and supplies blood to the head region. The two other arteries arise from the anterolateral sides and can be seen dipping into the base of the second pair of appendages. From the posterior part of the heart two arteries arise at about the same point in the middle line of the body, one dorsal, extending posteriorly through the abdomen on the dorsal side, and the other ventral, passing ventrally. These two blood vessels correspond to the abdominal and sternal artery, respectively, in the adult. The blood from the cephalothorax may be seen coursing back to the heart, along the border of the carapace. As no trace of gills exists in this stage, the blood must be aërated through the thin walls of the carapace.

In the adult the heart, viewed from the dorsal side, is roughly hexagonal. At its anterior end is the median cephalic artery (ophthalmic artery), on each side of which, arising from about the same trunk, is the lateral artery; at each anterior angle is

a hepatic artery. All these arteries pass forward. At the posterior end, arising at about the same point, are two median arteries: the sternal artery, which dips ventrad, and the posterior aorta, which passes caudad and above the intestine. At the origin of each artery there is a valve which prevents the blood from returning.

The cephalic artery (Plate 3, fig. 12, *o*) pursues a straight course over the pyloric and gastric portion of the stomach, then dips ventrad and splits into two main branches which supply the eyes, and to other parts of the frontal region. The lateral arteries (antennary) arise from the same trunk as the cephalic artery, then pass outward making an acute angle with the latter. The hepatic artery is a pair arising from the ventral side of the anterior angle of the heart. On leaving the heart, each dips ventrally and becomes embedded in the digestive gland. Near its origin it gives off a branch which supplies the hind gut. There are other small branches which supply various parts of the digestive gland.

The posterior aorta (superior abdominal artery) arises from the median posterior end of the heart, and just under this vessel is the descending artery.

This system requires further study in detail.

NERVOUS SYSTEM

The central nervous system (Plate 3, fig. 14; Plate 4, fig. 15) follows the same plan as that found in Macrura, consisting of: (*a*) a brain connected by commissures to (*b*) the subœsophageal ganglion, (*c*) a chain of thoracic ganglia, and (*d*) a chain of abdominal ganglia. It differs, however, from some macrurous types of nervous system in two principal aspects; first, instead of the usual five, distinct and equally prominent separate thoracic ganglia, as in *Penæus*, the first two thoracic ganglia are fused with the subœsophageal ganglion. Secondly, in the abdomen there are only five ganglia which are reduced in size. There are six of these in *Penæus*, and they are about as prominent as those of the thoracic ganglia.

The brain is formed of a complex mass of nerve cells and fibres. The nerve fibres become aggregated in the brain in definite masses or neuropiles ("Punksubstanz," Leydig). The principal neuropiles are: (*a*) the optic, *op;* (*d*) the superolateral, *dl;* (*c*) the superomedian, *dm;* (*d*) the globulus, *g;* and (*e*) the posterior neuropiles, *pm*.

The optic neuropiles each consisting of two lobes are situated at the anterior end of the brain, the posterior lobe bearing the optic nerve fibres and the oculomotor. The superolateral is a pair, each giving rise to the otocyst nerve fibres. Between this pair is the superomedian neuropile. From the ventral surface of this neuropile arises a nerve fibre which terminates in a swollen mass, which may possibly be regarded as a ganglion, lodged in the space beneath the median frontal lobe between the bases of the antennules. No mention is made in the literature available regarding a similar structure. Investigation concerning the nature, function, and, perhaps, phylogenetic homology may reveal some interesting facts. The aforementioned neuropiles compose the anterior half of the brain.

On each side of the posterior half is a very prominent globular mass, the globulus, to which are connected partly some of the fibres of the antennulary and the antennary. The tegumentary nerve fibre is attached to this mass. The posterior neuropile is continuous with the commissures. The visceral nerve fibres (v_1, v_2) arise from this neuropile.

The relations of the nerve masses and nerve fibres can be seen quite plainly on the ventral side of the brain (Plate 3, fig. 14). The following nerve fibres are connected with the brain:

Optic nerve (*o n*).—Each optic nerve arises from the dorsal side of the brain at its anterior angle. The fibres are continuous with those of the optic neuropiles. The nerve enlarges to form the optic ganglion in the eye peduncle. From this ganglion arise the nerve fibres that innervate the ommatidia of the eye.

Oculomotor nerve (*om n*).—The small nerve fibers that innervate the muscles connected to the eye peduncles arise from the ventral side of the optic neuropiles.

Antennulary nerve (at_1).—On the antennulary nerves some of the fibres originate from the ventral side of the optic neuropile and some from the globular mass. The antennulary nerve appears to be single, but is composed of two different kinds of fibres having different functions and arising from different centers in the brain. The main branch, innervating the antennules, arises from the ventral side of the brain. The branch that innervates the tactile organs seems to arise at the lateral side of the optic neuropile.

Antennary (at_2).—The antennaries are smaller than the antennularies, and innervate the antennæ. The fibres of these nerves seem to be derived from both the anterior and posterior half of the brain.

Tegumentary nerves (*tn*).—The tegumentary nerves are a pair of fairly big nerves arising from the globulus and passing outwards almost at right angles to the longitudinal axis of the body. They innervate the integument at the side of the body.

Visceral nerves (v_1, v_2).—There are two pairs of visceral nerves, and they may be regarded as the anterior and posterior nerve fibres. Both are connected to the posterior neuropiles. The anterior pair passes outwards to the anterior portion of the hepatic region, while the posterior pair passes over the gastric region.

Otocyst nerves (*ot n*).—The otocyst nerves on the dorsal side of the brain arise from the superolateral neuropiles. At a certain distance from the point of origin from the brain the two nerves are connected by a transverse nerve fibre. Above the transverse nerve a small nerve fibre branches out to supply the muscle that runs along the middorsal region of the body. The otocyst nerve terminates in a swollen mass, the otocyst ganglion, from which several fine nerve fibres branch out that possibly innervate the setæ in the otocyst sac. The function of this sac in some members of the crustacean group is still a matter of doubt. Some claim that it merely helps in maintaining equilibrium, while others hold that it is auditory in function.

Commissures (*co*).—The commissures are a pair of large nerve fibres, continuous with the posterior neuropiles, and passing posteriorly on each side of the œsophagus to the subœsophageal ganglion.

Subœsophageal ganglion (*s, g*).—The subœsophageal ganglion is situated just behind the œsophagus. It is formed by the fusion of the swollen terminals of the commissures. In its center may be seen the arterial foramen. Some of the nerve fibres connected to this ganglion are the stomatogastric nerves (*st n*) and some of the nerves that innervate the mouth appendages.

Thoracic ganglia (*th* g_1–*th* g_5).—At first glance only four ganglia are distinctly discernible, due to the fusion of the first and second thoracic ganglia with the subœsophageal ganglion, but by closer examination under the microscope the demarcation between these three ganglionic masses can be seen distinctly. A number of nerves arise from each ganglion innervating the corresponding region of the body and the corresponding appendages. The largest nerves are those that innervate the thoracic legs, except the one that goes to the fifth leg. This nerve is small and arises just behind the nerve that innervates the fourth leg.

The subœsophageal ganglion in Macrura is generally formed by the concrescence of the ganglia of the last three cephalic and the first three thoracic segments. In *Remipes* further fusion takes place, indicating distinctly a progressive evolutionary step toward further centralization from the macrural to the brachyural type.

Abdominal ganglia (*ab* g_1–*ab* g_5).—The tendency toward further centralization is supported by the reduction in number and in size of the abdominal ganglia. In typical Macrura there are six of these ganglia, about as prominent as the thoracic ganglia. In *Remipes* there are only five, and they are very much reduced in size, except the fifth which supplies the telson and the uropods.

SYSTEMATIC POSITION

Authors differ as to the classification and the relative affinities of the Hippidea. I shall only mention the views of four authors, because of their being more or less directly opposed to each other. Benedict(1) considers the Hippidæ and Albuneidæ to make up the superfamily Hippoidea of the Macrura anomalia.

Claus(2) rejects the suborder Anomura and refers the Hippidea to Brachyura on account of what is known of their development.

Dana,(3) tracing the relations of the different groups of Anomura to the higher types of Brachyura, concluded that they may with equal propriety be classified (*a*) "as in a linear descending series they deviate from the brachyural to the macrural type, or (*b*) according to their respective natural affinities with the higher brachyural subtribes."

In the former system the Hippidea are ranked by him with the Porcellanidea, as constituting the second section, *Anomura media,* of the tribe Anomura; in the latter they are classed as *Anomura corystidica,* immediately beneath the Corystidea, which are undoubtedly cancroid Crustacea.(13)

Miers,(13) commenting on Dana's view, remarks:

> With all deference to the opinion of the distinguished American naturalist, I must regard the older view as the more correct. I believe their true affinities are with the Oxystomatous Brachyura, through the Raninidea. They resemble this latter in their narrow and elongated form, natatorial legs, and in the case of the Albuneidæ in the high and laterally compressed hands of the anterior legs, which altogether resemble those of the Oxystomatous Calappa and allied genera. On account of the imperfect definition of the buccal cavity, it is easy to trace any resemblance either to the Cancroidea or to Oxystomata in the form of the mouth and oral ap-

pendages. There exists, however, an important characteristic and one, I believe, not hitherto noted, in the form of the terminal lobe of the exognath of the first pair of maxillipeds, which in the Hippidea, is elongated and narrow as in the Oxystomata, where it is usually applied to the opening of the afferent branchial channel. In the Cancroidea and Oxystomata, this joint is more or less obtriangular, short, and truncated at the distal extremity.

The conclusion of Miers is based on similarities in the form of the body, legs, and mouth appendages. Though these are significant and have their relative value, they are not sufficient to establish actual relationship between one animal and another, much less between one group and another, for they may be mere adaptive modifications, the results of the interplay between similar environmental conditions on one side, and on the other, between widely different animals—producing a resemblance not based on actual genetical relationship, but constituting a convergence. Supporting this line of argument is the fact that the members of the Oxystomata—the families Raninidæ, Leucosidæ, and Calappidæ, are generally sand diggers, like the members of the Hippidea. Living practically under identical ecological conditions, they face similar situations; namely, having to make their way into the sand and having to prevent sediment from clogging the buccal cavity and the branchial channel. Hence they have undergone adaptive modifications in the same direction.

Instances where animals had been placed wrongly because of some external resemblance to a group are too numerous to mention here. External evidence must be borne out by evidence in the internal organizations of the animal, and the more reliable criterion for determining the relative affinity between animals is the organization of the nervous system.

Jones(8) says,

There can be no doubt that the nervous matter must be regarded as the very essence or being of all creatures, with which their sensations, volition and capability of action are inseparably connected; and such being the case, it is a legitimate inference that the capacities and powers of the several tribes are in immediate relation with the development and perfection of this supreme part of their organization, and their entire structure must be in accordance with that of the nervous apparatus which they possess.

From what is shown in the degree of centralization, it is obvious that the organization of the central nervous system of *Remipes* is only slightly in advance over that of a prawn, a macruran, which consists in the coalescence of the first and second

thoracic ganglia with the subœsophageal ganglion, and in the reduction in size and number of the abdominal ganglia.

As a basis for comparison, let us take the organization of the nervous system of the spiny lobster, *Panulirus versicolor* (Latreille) (Plate 4, fig. 22). In this animal the subœsophageal ganglion had fused with the first three thoracic ganglia, hence the fusion has gone a little further than what has taken place in *Remipes*. *Panulirus* is distinctly macrurous in character, and I am not aware of any systematist who claims otherwise. However, while centralization in the thoracic ganglia has gone further in *Panulirus*, this process lagged behind relative to the abdominal ganglia, of which there are still six, whereas there are five in *Remipes*, in which this character may be viewed as a corresponding adaptive response to its particular habitat. To successfully bore its way through the sand, an animal must not only have its abdomen flexed but also be reduced in size.

An illustration of further concressence beyond that observed in *Remipes* and *Panulirus* is the nervous system of the coconut crab, *Birgus latro* (Linn.), an anomuran. In this animal all the thoracic ganglia have fused to form one mass, and the abdominal ganglia, though still distinct, have undergone further reduction in size (Plate 4, fig. 20).

The process of centralization, insofar as it has taken place in Crustacea, reaches its climax in Brachyura. Plate 4, fig. 21(16) shows the nervous system of a representative of this group. All the thoracic and abdominal ganglia become agglomerated into one mass, the ventral nerve mass from which nerves radiate to the thoracic and abdominal appendages.

If *Remipes* is placed under Anomura, it certainly should occupy a position on the lower rung of the scale, below that of Paguridea. Benedict's creation of the superfamily Hippoidea of the Macrura anomalia appears to have more justification than Dana's Anomura media, with a position close to Brachyura. By virtue of the possession of a higher degree of nervous centralization, the tribe Paguridea as represented by the coconut crab is more entitled to this position.

On the basis of progressive cephalization as indicated in the nervous organization it seems to me the more legitimate position for Hippidea as represented by *Remipes testudinarius* is with the Macrura; they may be regarded as an aberrant group of the division Phyllobranchiata. They agree with this division in having the branchial plumes in the form of broad foliaceous

plates attached to a central stalk. The degree of centralization shows an advance over that of a prawn, but less than the advance of *Panulirus*, another macruran.

However, the members of the two families Hippidæ and Albuneidæ, of the tribe Hippidea, resemble the anomurans in many respects, principally in the reduction in the size of the abdomen and in the manner in which this part is held under the body. On the other hand, their large and prominent telson and uropods, and their separate and distinct abdominal pleura except the fifth and sixth which are fused (in *Remipes*), point to their macrural affinity.

They also resemble the brachyurans in several aspects: (*a*) in the relative flattening of the body dorsoventrally; (*b*) in the greater prominence of the cephalothorax; (*c*) in the character of the legs, and (*d*) in the character of the mouth appendages. It is on the basis of these last two that Miers associates them with the oxystomatous brachyurans through the Raninidea.

While these facts are significant and undoubtedly have their merit in the consideration of affinities among animals, we should not lose sight of the deeper internal structural organization, ideally that of the nervous system, which is generally considered the more reliable index of the degree of organization in animals, and consequently, of their relative affinities. Indeed, as a general rule, it is customary to arrange animals in an ascending scale according to the degree to which the nervous system is developed.

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ILLUSTRATIONS

FIG. 1. Antennule (first antennæ), ventrolateral view; × 6. *a*, Basal segment of peduncle; *b*, second segment of peduncle; *c*, distal segment of peduncle; *d*, basal segment of secondary (ventral) flagellum; *e*, basal segment of primary (dorsal) flagellum; *f*, secondary flagellum; *g*, primary flagellum; *tr b*, tactile bristles.

2. Antenna, ventrolateral aspect; × 6. *a*, Basal segment of peduncle; *b*, second segment of peduncle; *c*, distal segment of peduncle; f_1, primary flagellum (dorsal); f_2, secondary flagellum (ventral).

3. Mandible, dorsolateral view; × 10. *a*, Basal portion; *b*, outer portion of palpus; *c*, inner branch of palpus; *d*, lateral spinous margin of basal portion of palpus.

4. First maxilla (enlarged), ventral view. *a*, Protognathal portion of endopodite; *b*, protognathal lobe; *c*, exopodite; *d*, muscle.

5. Second maxilla, inside view; × 2. *ex*, Scaphognath, gill bailer; *en*, endognath; *b*, basipodite.

PLATE 2

FIG. 6. First maxilliped, left side, inner surface; enlarged. *a*, Basal attachment; *b*, proximal segment of exopodite; *c*, terminal segment of exopodite; *d*, endopodite.

7. Second maxilliped left side, inner surface, enlarged. *a*, Basal attachment; *b*, protognathal lobe; *c*, first segment of endopodite; *d*, first segment of exopodite (flabellum).

8. Third maxilliped, left side, inner surface; enlarged. *a*, Basal attachment (basi-ischiopodite); *ex*, exopodite.

9. Dorsal view, abdomen and telson stretched out. a_1, Antennule, first antenna; a_2, antenna; per_1, first pereiopod; per_2, second pereiopod; per_3, third pereiopod; per_4, fourth pereiopod; max_3, third maxilliped; *t*, telson; *u*, uropod.

10. Abdomen, telson stretched out, ventral view, × 0.9. per_5, Fifth pereiopod; ap_1, first abdominal pleuron; *a ap*, anal aperture; *u*, uropod; *t*, telson.

PLATE 3

FIG. 11. Reproductive system of male; × 2. *te*, Testis; *vd*, vas deferens; *s v*, seminal vesicle; *g p*, genital papilla; *f*, spooned finger of fifth pereiopod.

12. Heart and vessels; enlarged. *e*, Artery to eye; *o*, ophthalmic artery (cephalic); *at*, lateral artery (antennary); *g*, gastric artery; *h*, hephatic artery; *p g*, posterior gastric; *ab*, abdominal artery; *st*, sternal artery; *bc v*, branchiocardiac vein; *ib s*, infrabranchial sinus.

FIG. 13. Gill; enlarged. *st*, Arthrodial membrane fold attaching gill to base of gill-bearing appendage; *c*, horizontal stalk; *fp*, one of the foliaceous plates.

14. Brain, subœsophageal ganglion, one of thoracic ganglia, ventral view, enlarged. *p g*, ganglion; *ot g*, otocyst ganglion; *ot n*, otocyst nerve; *om n*, oculomotor nerve; *on*, optic nerve; at_1 antennulary nerve; at_2, antennary nerve; v_1, v_2, visceral nerves; *co*, commissures; *st n*, stomogastric nerves; *s g*, subœsophageal ganglion; *af*, arterial foramen; mx_3, nerve to third maxilliped; th_1, first thoracic ganglion; pn_1, nerve to the first pereiopod.

PLATE 4

FIG. 15. Central nervous system, with anterior portion to second thoracic ganglion more enlarged than posterior; dorsal view. at_1, antennulary nerve; at_2, antennary nerve; *t n*, tegumentary nerve; v_1, v_2, visceral nerves; *g*, globulus; *p m*, posterior neuropyle; *p g*, ganglion; *ot g*, otocyst ganglion; *ot n*, otocyst nerve; *dl*, dorsolateral neuropile; *op*, optic neuropile; *dm*, superomedian neuropile; *om n*, oculomotor nerve; *o n*, optic nerve; *co*, commissure; *st n*, stomogastric nerves; *s g*, subœsophageal ganglion; *af*, arterial foramen; *th* g_1–*th* g_3, thoracic ganglia; pn_1–pn_5, nerves to pereiopods (walking legs); mx_3, nerve to the third maxilliped; *ab* g_1–*ab* g_5, abdominal ganglia; *u n*, nerve to uropods; *cd*, caudal nerve.

16. *a*, Egg undergoing cleavage (enlarged); *b*, section.

17. Older embryo still attached to pleopod of mother (enlarged). *a*, Stalk, a drawn-out portion of chorionic membrane of embryo; *b*, eye spots.

18. Nauplius; enlarged. *a*, Rostrum; *b*, eye, developing; *c*, abdomen.

19. First zœa, shed by the mother a few hours after capture. *a*, Rostrum; *b*, eye; *c*, mouth appendage; *d*, abdomen; *e*, telson.

20. Nervous system of coconut crab, *Birgus latro* (Linn.). After F. Nemenzo. *o*, Optic nerve; *al*, anterior lobe of brain; *a*, antennulary nerve; *at*, antennary; *p l*, posterior lobe of brain; *cc*, circumœsophageal connective; *p c*, postœsophageal commissure; *s*, ganglionic mass in circumœsophageal connective; *s n*, sympathetic nerve; max_1, nerve to the first maxilla; max_2, nerve to second maxilla; mlp_1, nerve to first maxilliped; mlp_2, nerve to second maxilliped; mlp_3, nerve to third maxilliped; p_1 nerve to first pereiopod; p_2, nerve to second pereiopod; p_3, nerve to third pereiopod; p_4, nerve to fourth pereiopod; p_5, nerve to fifth pereiopod; *th g*, thoracic ganglionic mass; *st*, arterial foramen; abd_1, first abdominal ganglion; *abd c*, abdominal nerve cord.

21. Nervous system of a crab, *Cancer pagurus*. After Joseph Pearson, 1908. *c g*, Cerebral ganglion; *a n*, nerve to first antenna; a_2 *n*, nerve to second antenna; *o n*, optic nerve; *o m n*, ocular motor nerve; *t n*, tegumentary nerve; *p g*, parœsophageal ganglion; *n m*, nerve to mandibular muscle; *n p o*, transverse postœsophageal connective; *œ*, œsophagus; *com*, commissure; *t g*, ventral thoracic nerve mass; *n f*, foramen of ventral

nerve mass for descending artery; *n ab*, abdominal nerve; *st s*, superior root of stomatogastric nerve; *st i*, inferior root of stomatogastric nerve; *st n*, stomatogastric nerve; *st g*, stomatogastric ganglion; *l g n*, lateral gastric nerve; *p g n*, posterior gastric nerve; *nt*, nerve to integument; *n i*, nerve to hind gut; *n l*, nerve to digestive gland; n_1–n_6, nerve arising from ventral nerve mass.

22. Nervous system of *Panulirus versicolor* (Latr.); ventral view. After D. K. Villaluz, in MS. *o*, Optic nerve; *a*, antennulary nerve; *a t*, antennary nerve; *s o g*, supraœsophageal ganglion or brain; *c c*, circumœsophageal connectives; *œ*, œsophagus; *m*, mandibular nerve; mx_1–mx_2, first and second maxillary nerves; p_1–p_5, first to fifth pedal nerves; *sub o g*, subœsophageal ganglia; *st*, perforation for passage of sternal artery; 1–6, abdominal ganglia; *ab c*, abdominal nerve cord.

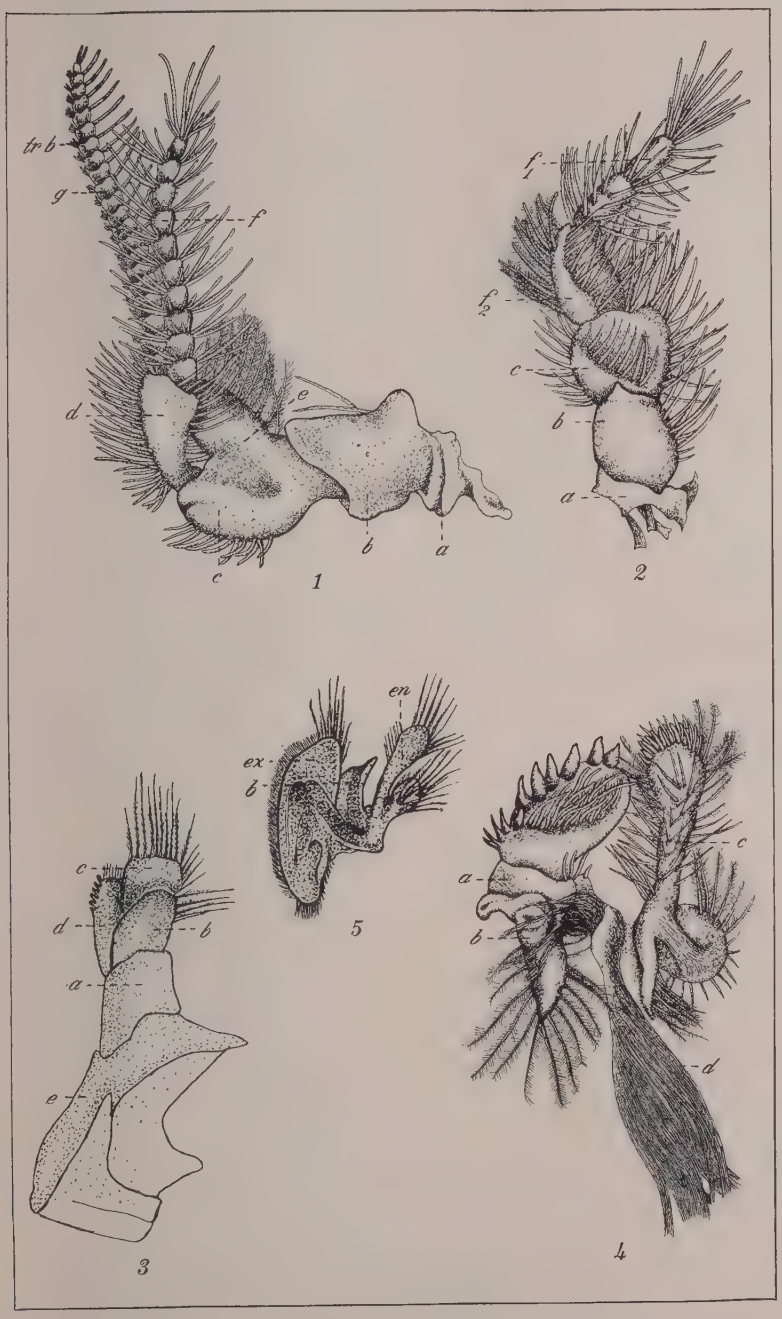

PLATE 1. REMIPES TESTUDINARIUS LATREILLE.

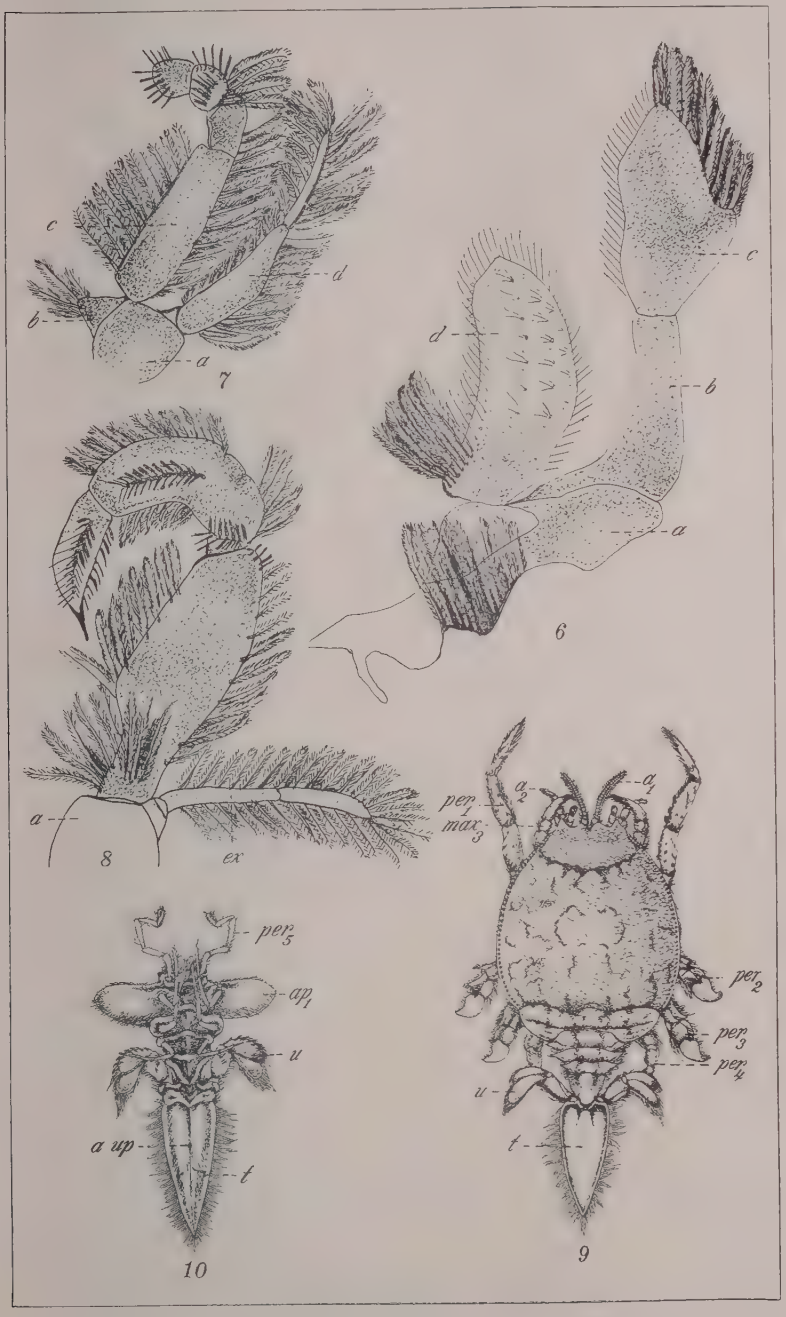

PLATE 2. REMIPES TESTUDINARIUS LATREILLE.

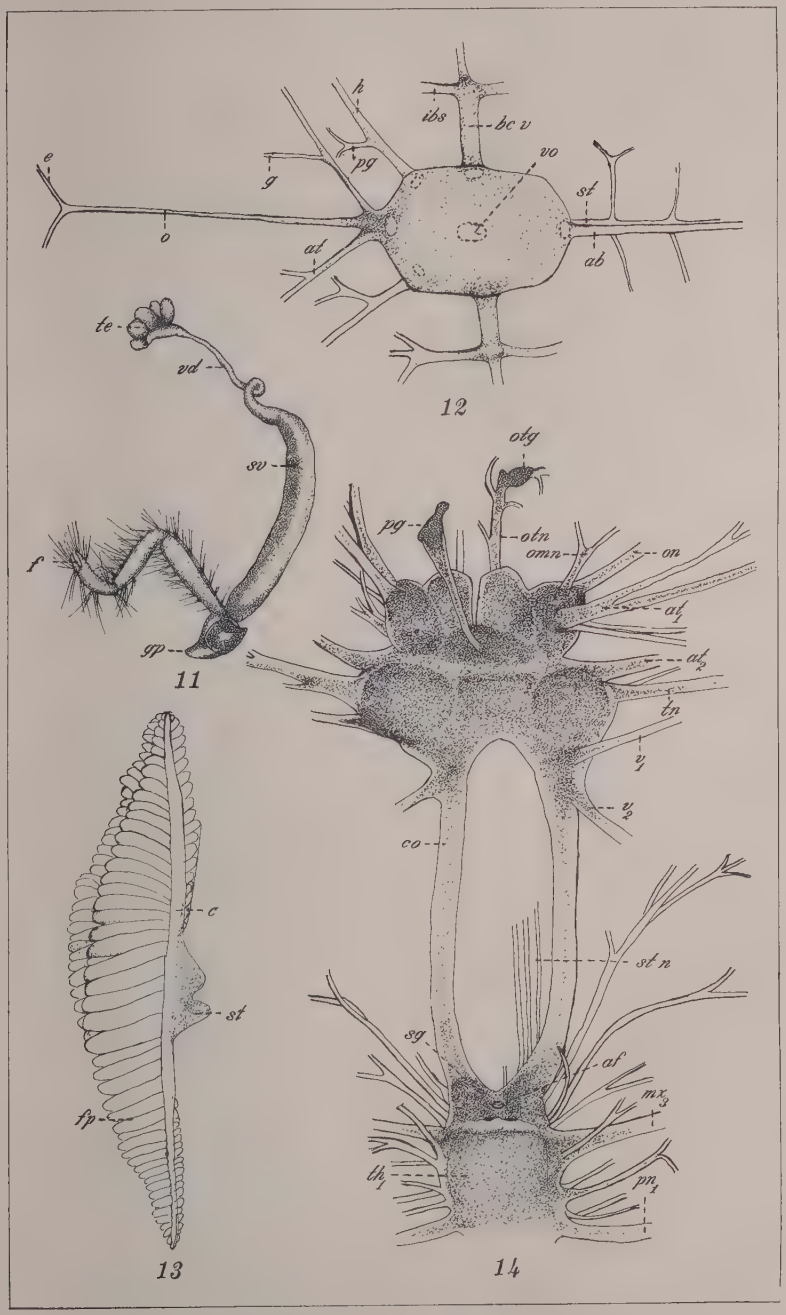

PLATE 3. REMIPES TESTUDINARIUS. LATREILLE.

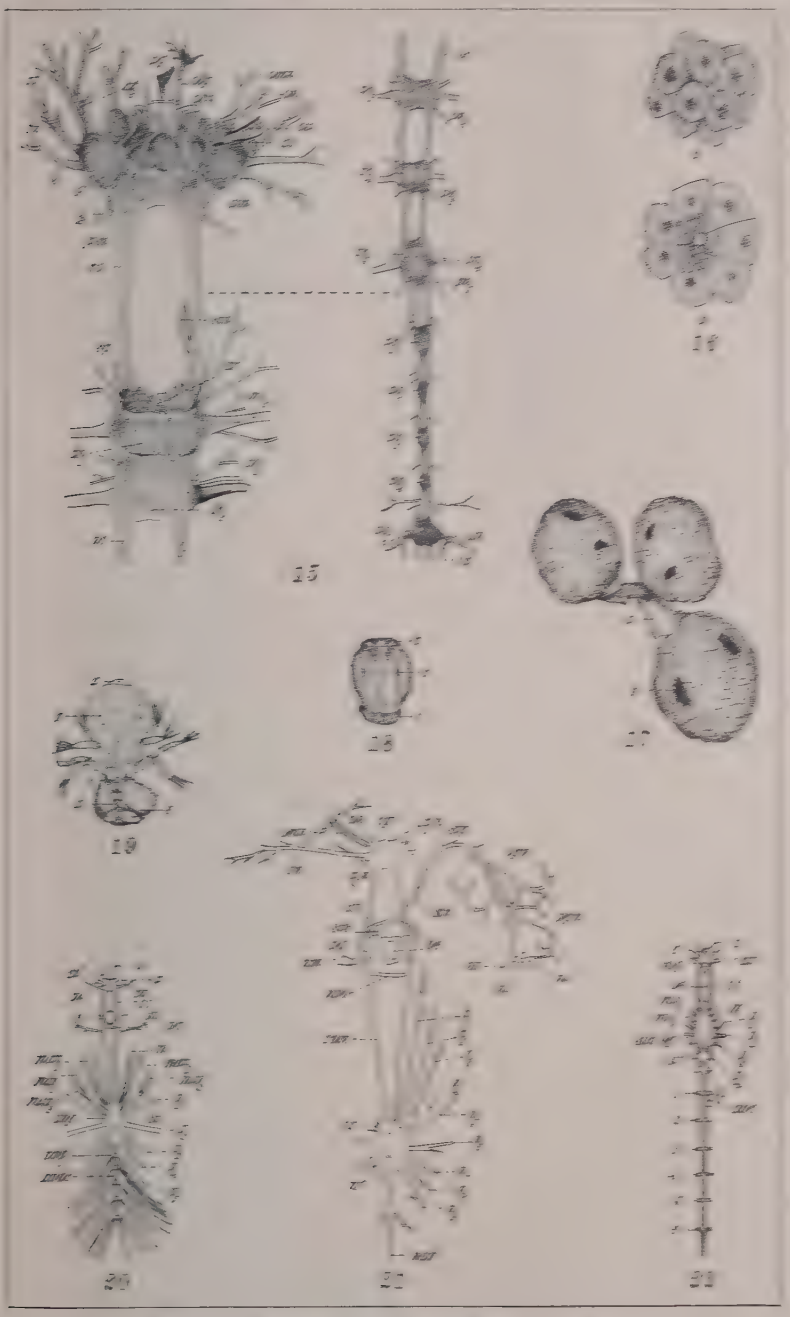

PLATE 4. REMIPES TESTUDINARIUS LATREILLE.

BOOKS

Books reviewed here have been selected from books received by the Philippine Journal of Science from time to time and acknowledged in this section.

REVIEWS

Cytological Technique. By John R. Baker. London, Methuen & Co. Ltd., 1933. 131 pp., illus. Price, 3s. 6d.

Teachers and other persons interested in biology will find in this little book a brief authoritative discussion of the various techniques involved in the preparation of cells and tissues for microscopic examination. The chapters on fixation and staining, which comprise the bulk of the book, will be found most interesting by those desiring a basic knowledge of the composition and uses of some of the more common fixing fluids and staining reagents.

The book contains a number of bibliographic references.

—M. T.

1001 Garden Questions Answered. By Alfred Carl Hottes. New York, A. T. de la Mare Company, 1938. 2d Ed. 320 pp., illus.

In any garden various problems connected with soil, plants and their enemies, garden accessories, and weather are encountered. Prof. Alfred Carl Hottes furnishes solutions for most of them in his little book. Although the book is intended primarily for temperate or semitemperate climate, it includes some problems in tropical gardens. The plants treated are mostly of the temperate regions, but troubles of tropical plants similar to those of the temperate species and their remedies are found in the book, which also deals with difficulties in the culture of vegetables and ornamental annuals and trees.

The book is copiously illustrated with sketches and photographs, and well indexed. It is a valuable and handy manual for a gardener, especially for a beginner in gardening.

The calendar or advice on what to do in the garden each month, though useful, seems to be difficult to follow in the Tropics. However, it could serve as a guide in the preparation of a similar calendar for the Tropics.

In addition to ornamental gardening the book also discusses vegetables, fruits, and miscellaneous topics such as plant breeding, engineering, geometrical calculations, carpentry, and other routine necessary in keeping a garden. It should be of value to ornamental gardeners and to those who contemplate making a garden.—V. M. D.

Pneumonia and Serum Therapy. By Frederick T. Lord and Roderick Heffron. Revised Edition of Lobar Pneumonia and Serum Therapy. New York, The Commonwealth fund, 1938. 148 pp. Price, $1.

This book is a clear presentation of the investigation carried out by Dr. F. T. Lord on the treatment of the acute pulmonary disease known as pneumonia by its specific antipneumococcus serum. The first chapter offers thorough information about the control program that is being carried out by various government agencies to accomplish effective treatment and control of pneumonia.

It discusses fully the clinical manifestations of a typical case of pneumococcus pneumonia as well as the different types of the causative pneumococci. The author gives special attention to the symptomatology, pathogenesis, epidemiology, immunity, diagnosis, and treatment of this disease. The reader can also obtain a general idea concerning the methods of manufacturing antipneumococcus serum from horses and rabbits, as well as instructions regarding the correct technique for administering the antipneumococcus serum in the treatment of pneumonia. The book also gives all the indications and contra-indications in the use of serum therapy and its possible results.

This book is a valuable guide for physicians in the treatment of this disease.—P. J. A.

Industrial Minerals and Rocks (Nonmetallics other than Fuels). Edited by the Committee on the Industrial Minerals Volume, Samuel H. Dolbear, Chairman Oliver Bowles, Vice-chairman, and others. Sponsored by the Seeley W. Mudd Memorial Fund. New York, The American Institute of Mining and Metallurgical Engineers, 1937. 955 pp., front., illus. Price, $6.

This new volume is a valuable contribution to existing literature on nonmetallic industrial minerals and rocks, except mineral fuels. Each chapter contains comprehensive information pertaining to the geologic occurrence, geographic distribution, political and economic control, production and consumption, method of mining, preparation for market, industrial uses, marketing, and prices. It is reported that not less than 70 of these

minerals, commonly known as "nonmetallics," are mined and used in industry.

It is pointed out that, while these nonmetallics rapidly increase in importance, many of their superficial deposits face a gradual exhaustion. To cope with that situation and to effect a profitable exploitation of these resources, more elaborate and effective methods of mining and processing are urged. These will require the employment of well-trained technical men to manage the operations.

To assist students and young engineers to take advantage of the opportunities in this broad and fertile field is one of the purposes behind the publication of this volume which was sponsored by the Seeley W. Mudd Memorial Fund. Each chapter is written by a specialist on the subject. There is a bibliography at the end of each chapter. This book will be useful to engineers, technologists, business men, and students in the mineral industries.—B. R. S.

Metallurgy. By Carl G. Johnson, R. S. Dean, and J. L. Gregg. Chicago, American Technical Society, 1938. 149 pp., front., illus. Price, $1.50.

This book is essentially a compilation of available up-to-date knowledge pertaining to the manufacture and behaviour of metals and alloys. The important physical aspects of metallurgy, such as constitutional diagrams, shaping operations, and the physical and chemical properties of metals resulting from the hot and cold treatments, have been stressed, rather than the chemical process of melting and refining. Most of the modern equipment used is briefly described. An interesting discussion in the latter part of the book deals with the powder process of manufacturing alloys by the application of pressure and heat treatment. By this process it is now possible to manufacture many mixtures of metals which cannot be prepared by the usual melting process, especially metals whose melting points are higher than that of any known refractory.

This book is well illustrated, nontheoretical, and written in a style and language interesting and easy to understand. Laymen and students of engineering will find in this text a practical and valuable guide.—B. R. S.

The Environment and Its Effects Upon Man. Symposium held at Harvard School of Public Health August 24–August 29, 1936, as part of the Harvard University Tercentenary Celebration 1636–1936. Boston, Harvard School of Public Health, 1937. 297 pp., illus.

The book touches on the effects of social environment; industrial fatigue; air-borne infection; effect of heat and humidity and various abnormal conditions in industry, and methods of control; air conditioning; and organization of laboratories of industrial toxicology and hygiene.

These collected works should be read by public health workers and teachers of hygiene and preventive medicine, especially by those who are interested in the application of physiology to the prevention and control of ill health and inefficiency among industrial workers.

The treatment of the many aspects of industrial physiology and hygiene is most frank and thought provoking.

References are found at the end of each work.—M. L.

A Symposium of Cancer. By Leiv Kreyberg and others. Madison, University of Wisconsin Press, 1938. 212 pp. Price, $3.

This book contains papers dealing with the different aspects of cancerology. It gives the reader an insight into the results of investigations in experimental biology made in recent years which throw some light on the causation and production of cancer; clinical facts dealing with radiotherapeutics as worked out and observed by Coutard, and some points with regard to cancer as a public-health problem. The authors mention also the influence of wave lengths of radiation to the disease. In short, the book brings to us the work, observations, and experiences of a well-known group of men competent to discuss cancer.—P. S. C.

On Your Guard! The Prevention and Treatment of Sex Diseases. By Carl Warren. Foreword by M. J. Exner. New York, Emerson Books, Inc., 1937. 160 pp., front., illus. Price, $1.

This little book on sex hygiene is written in a language very understandable to the layman.

The work touches in an interesting manner, amongst other things, on the incidence of venereal diseases by geography, sex, age, occupation, economic status, and race; venereal prophylaxis; proper ways to obtain, test, and handle mechanical preventive devices; symptoms and treatment of venereal diseases; and how to avoid the perils of quacks and nostrums.

The book includes many illustrations.—H. L.

RECEIVED

American medical association interns' manual. Edited by the council on medical education and hospitals and the council on pharmacy and chemistry of the American medical association. Chicago, American medical association, 1938. 229 pp.

American medical association. New and nonofficial remedies, 1938, containing descriptions of the articles which stand accepted by the council on pharmacy and chemistry of the American medical association on January 1, 1938. Chicago, American medical association, 1938. 590 pp., biblio., index.

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American society for testing materials. 1938 supplement to book of A. S. T. M. standards. Philadelphia, American society for testing materials, 1938. 241 pp., illus. Price, paper, $2.

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DUBLIN, LOUIS I., and ALFRED J. LOTKA. Twenty-five years of health progress. A study of the mortality experience among the industrial policyholders of the Metropolitan Life Insurance Company, 1911 to 1935. New York, Metropolitan Life Insurance Company, 1937. 611 pp., illus.

GUNTON, H. C. Nature study above and below the surface. A bridge between amateur and professional. With a preface by Dr. C. B. Williams, M. A., D. Sc. London, H. F. & G. Witherby, ltd., 1938. 134 pp., pl., illus. Price, 7s. 6d.

HATCHER, ROBERT A., and others. Epitome of the pharmacopeia of the United States and the national formulary with comments corrected and revised in accordance with the first supplement of the pharmacopeia, eleventh revision, and the first and second correction lists of the national formulary, sixth edition. Prepared for the use of physicians under authorization of the council on pharmacy and chemistry of the American medical association by a committee of council members: Robert A. Hatcher, Ernest E. Irons, Torald Sollmann, Paul Nicholas Leech. Chicago, American medical association, 1938. 244 pp.

HATCHER, ROBERT A. Useful drugs. A selected list of essential drugs with brief discussions of actions, uses, and dosage. Edited under the direction and supervision of the council on pharmacy and chemistry of the American medical association. Chicago, American medical association, 1938. 11th ed. 258 pp. Price, $0.75.

JOHNSON, CARL G., R. S. DEAN, and J. L. GREGG. Metallurgy. Chicago, American technical society, 1938. 149 pp., illus. Price, $1.50.

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ROBERTS, HARRY. The troubled mind. A general account of the human mind, and its disorders and their remedies. With chapters on the

insanities by Margaret Nelson Jackson. London, John Murray. 1938. 284 pp. Price, 6s.

RYAN, W. CARSON. Mental health through education. New York, The Commonwealth fund, 1938. 315 pp. Price, $1.50.

SUTHERLAND, JOHN PRESTON. Malnutrition the medical octopus. Boston, Meador publishing Co., 1937. 368 pp. Price, $3.

SWELLENGREBEL, N. H., and A. DE BUCK. Malaria in the Netherlands. Amsterdam, Scheltema & Holkema, ltd., 1938. 267 pp., illus.

VAN REENEN, REENEN J. Resisting drought. Pretoria, The Government printer. 1935. 221 pp., front., illus.

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CONTENTS

The articles in the Philippine Journal of Science are indexed in the International Index to Periodicals, New York, N. Y.